CHARACTERISTIC OF POLY LACTID ACID (PLA)/ COIR WITH ADDITION OF CHITOSAN VARIATIONS FOR REVIEWING PLASTIC MATERIALS

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ABSTRACT

Poly lactic acid or poly lactide (PLA) is a natural polymer that is biodegradable, thermoplastic and is an aliphatic polyester made from renewable materials such as young kepok banana starch. Poly lactic acid with the chemical formula CH3CH(OH)COOH is a biodegradable polymer obtained from the combination of lactic acid monomers. Therefore, in this study the PLA polymer as a matrix was added with fillers in the form of Coir and Chitosan. Coir is a coconut fiber that has been widely used by researchers for decades. Chitosan has been widely used as an important and promising biopolymer material in tissue engineering because of its anti-microbial activity, biodegradability, biocompatibility, and non-toxicity. The characteristics resulting from the combination of these three materials resulted in 4 samples, namely the fixed variable PLA with variations of Coir and Chitosan. Sample 1 Coir/Chitosan (90:10 (%)) produces a tensile strength value of 80 MPa. Sample 2 Coir/Chitosan (80:20 (%)) yielded a tensile strength of 55 MPa. Samples of 3 Coir/Chitosan (70:80 (%)) yielded a tensile strength of 48 MPa. Samples of 4 Coir/Chitosan (60:40 (%)) produced a tensile strength of 30 MPa. The FTIR test on sample 1 resulted in a new compound found in the PLA/Coir/Chitosan composite, namely the compound N=C=O which is an isocyanate group at the peak of the 2279.86 cm-1 group. While the SEM test which shows the physical structure of the sample composition of PLA with the addition of Coir/Chitosan (90:10%) is the sample with the best morphology.

Keywords: Poly Lactid Acid, Coir, Chitosan, Polymers

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1. INTRODUCTION

Lately, environmentally friendly technology has been popular among researchers to further research on renewable materials as a substitute for petroleum in the world. As we know that the availability of petroleum in the world is increasingly limited. By looking at these limited conditions, of course, the longer the world's oil stock is getting thinner, and it is feared that in the future it will run out if environmentally friendly technology is not intensified from now on.

PLA is one of the materials that is considered as the most potential bioplastic to be applied. Poly Lactid Acid (PLA) has attractive properties such as biocompatibility, high strength, rigidity, and thermoplastic, but has low impact strength. Poly lactic acid (PLA) is an alternative to fossil-based polymers with less environmental impact. PLA can be mixed with other resins or added with different fillers such as fibers, micro and nano particles.

Improvement of PLA research from 1990 to 2021

Figure 1

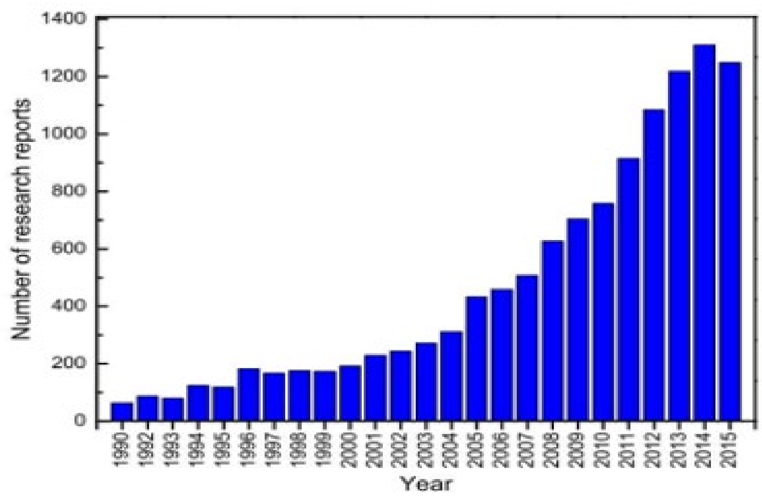

Figure 1 Number of Research Reports Published Since 1990

The use of PLA for applications such as fiber, textile, plasticulture, food packaging has been used. However, the use of PLA as food packaging for products is still relatively short-lived, as an environmentally friendly plastic raw material, it has been investigated that this biopolymer has weaknesses, one of which is its low melting point compared to other plastic polymers. Ridwan et al. (2018)

Therefore, to overcome these weaknesses, PLA can be improved by adding fillers. As for this study will use a filler in the form of coir (coconut coir). In the last few decades, much research on biocomposites consisting of plant fibers and biogradable polymers have been carried out. Suryani et al. (2018) Coir (coconut coir) was apparently used as a thermoplastic reinforcement with the aim of increasing the poor surface adhesion between fiber and starch with a high polar character. Suryani et al. (2018). Therefore, in this study coir was used as a filler to see the characteristics of the material as a bioplastic packaging material.

Sun et al. al, studied the mal and mechanical properties of polylactic acid biocomposites and found that these properties were enhanced by the introduction of treated coir fibers. Rihayat et al. (2018).

Chitosan has been widely used as an important and promising biopolymer material in tissue engineering because of its anti-microbial activity, biodegradability, biocompatibility, and non-toxicity. However, it is not an ideal material for tissue engineering as its bioactivity needs to be tissue-specifically enhanced. One of the methods used to modify chitosan is to convert it into nanoform. Nanochitosan has several unique properties such as high surface reactivity, non-toxicity, small size, and environmentally friendly materials. The nano-sized particles are soft and brittle in nature Rihayat et al. (2018).

Furthermore, in accordance with the improvement of packaging material quality standards, the addition of materials that prevent migration on the surface of the material is something that cannot be avoided. Chitosan is a polysaccharide obtained by deacetylation of chitin and has many applications due to its excellent oxygen blocking properties, antimicrobial properties, biodegradability, biocompatibility, and non-toxicity. One of the important properties of chitosan is the ability to interact with cells and cellular lysozyme which is able to degrade microbes in vivo. Gokila et al. (2018)

So, this study discusses the development of plastic materials made from PLA as a matrix, Coir and Chitosan as a filler. The formulations that will be used are young kepok bananas, 0.05% tin octoate catalyst, HCl (Hydrochloric acid), Lactobacillus bulgaricus bacteria.

2. METHODOLOGY AND CHARACTERIZATION

2.1. MATERIALS

The material used is PLA which is synthesized using raw materials for young kepok bananas, Coir (coconut coir), Chitosan. Other additional ingredients are young kepok bananas, 0.05% tin octoate catalyst, HCl (Hydrochloric acid), Lactobacillus bulgaricus bacteria.

2.2. METHODOLOGY

In this study, the synthesis of PLA (Poly Lactic Acid) which is made from young kepok bananas will be carried out first. In the process of making Poly lactic acid / PLA from cassava, there are several main process stages, namely:

2.2.1. PREPARATION OF PLA (POLY LACTID ACID)

1) Extraction of starch

The young kepok bananas that have been provided are peeled and cut into thin slices with a thickness of ± 3-5 mm. Young kepok bananas were weighed as much as 500 grams, put into a blender, and added 1,500 ml of distilled water. The banana and aquadest mixture is then blended for 10 minutes. The banana pulp is then filtered using a cloth filter. The filter results are accommodated in a container and left for 8 hours until there is a precipitate at the bottom of the container. Liquids and solids are separated by decantation. The liquid obtained was collected in another container and re-deposited for 8 hours. Liquids are separated from solids by decantation. The starch obtained was then dried in an oven at 40°C until dry. The starch was then sieved and weighed to determine the amount of starch obtained.

2) Hydrolysis of starch to glucose

The hydrolysis is carried out using a series of tools as shown in Figure 2 A total of 100 grams of starch produced was put into a three-neck flask and added 150 ml of 5% HCl, then stirred at a constant speed of 350 rpm. The solution was heated to a temperature of 60°C and kept constant for 180 minutes to obtain a glucose solution Wahyudi, et al. (2011).

3) Glucose Test

Glucose that has been produced from the hydrolysis process was tested using Benedict's reagent to prove the presence of glucose in the sample. 4 clean test tubes are prepared. The solution to be tested is put into a test tube as much as 5 drops with a glucose sample level of 1%. Then 15 drops of Benedict's reagent were added into the test tube and stirred until homogeneous. All test tubes that have been filled are put into boiling water and left for 5 minutes. After 5 minutes, the test tube was removed and cooled for a while. Observe the color formed in the precipitate. A positive reaction is indicated by the formation of a blue-green, yellow or brick red precipitate, depending on the reducing sugar content.

4) Glucose Fermentation

The glucose obtained was fermented for 72 hours using the help of Lactobacillus bulgaricus microbes to produce lactic acid. The resulting lactic acid is then polymerized to form Poly (Lactic Acid).

5) Lactic Acid Polymerization

Lactic acid polymerization was carried out using the Ring Opening Polymerization (ROP) method. This process involves three different steps, namely lactic acid polycondensation/prepolymerization, depolymerization to form cyclic dimers (lactides) and ring opening polymerization. Stannous octoate (Sn(Oct)2) was used as a catalyst. In the first stage, 10 ml of lactic acid was put into a neck Erlenmeyer then connected to a vacuum suction with a pressure of 300 mmHg and heated to 100°C using a hotplate stirrer with a rotor speed on a speed scale of 3 of 5 for 2 hours. During the process, the temperature is controlled to remain stable.

In the second stage, the prepolymer formed was added as much as 0.05% tin octoate catalyst, then heated and stirred with a rotor speed on a speed scale of 3 of 5 and connected to a vacuum suction with a pressure of 300 mmHg for 2 hours.

In the third stage and is the end of the reaction, the resulting lactide crystals are weighed 1 gram. Lactide crystals were put into Erlenmeyer and added as much as 0.15% catalyst, 0.4% glycerol and heated by condensation at a temperature of 120°C under vacuum for 2 hours.

2.2.2. COIR PREPARATION

At the preparation stage, tools and materials provide all the tools and materials needed during the research process. Furthermore, preparing the fiber before carrying out the material synthesis process by giving special treatment to the fiber to clean and change the size of the fiber. The treatment given is in the form of an alkalization process. According to Bifel et al. (2015), the alkalizing process of coconut fiber is soaked with a mixture of Aquades and 5% NaOH for 2 hours to produce coconut fiber which has the highest mechanical value. After the soaking process is complete, the coconut fibers are blended along with a mixture of lye for 20 minutes. Then the fiber was washed until the alkaline liquid disappeared and dried in an oven at 100ºC for 1 hour.

2.2.3. SAMPLE PREPARATION

Synthesis of materials is carried out by mixing matrix and filler. Where in this study, a matrix of poly lactid acid was used which was synthesized from young kepok bananas and the fillers used were coir and chitosan. First prepare a container to sample the PLA/Coir mixture with a consistent weight. Add chitosan with various variations.

2.3. CHARACTERISTICS

2.3.1. TENSILE TEST

The tensile strength of PLA/Coir and Chitosan was tested using a tensile tester with the procedure in accordance with ASTM D 638 – 99. According to the ASTM D 638 standard specimen, the mechanical properties were tested in the form of the level of tensile strength through the axial force provided by the tensile test equipment until it reached the maximum limit. until disconnected. Engineering tensile tests are mostly carried out to complete basic design information on the strength of a material and as supporting data for material specifications. In the tensile test, the test object is given a continuous increase in the axial tensile force load, at the same time an observation is made on the elongation experienced by the test object.

2.3.2. FTIR TEST

The infrared spectrum at room temperature was tested using a Shimadzu Fourier Transform Infrared (FTIR) Spectrophotometer in the range of 4,000-500 cm-1 for 16 recordings using a resolution of 4 cm-1.

2.3.3. SEM TEST

The inner morphology of PLA/Chitosan Nanocomposites was tested using a Shimadzu Scanning Electron Microscope (SEM) at a voltage acceleration of 15 kV. Before the SEM analysis was carried out, the sample was coated with gold sparks Buzarovska (2015).

3. RESULTS AND DISCUSSION

In this study, the best results from the tests that have been carried out will be presented. The following is a table of observations using the Tensile Test (Tensile Strength), Functional Groups (FT-IR), Tensile Test.

3.1. TENSILE TEST ANALYSIS

Figure 2

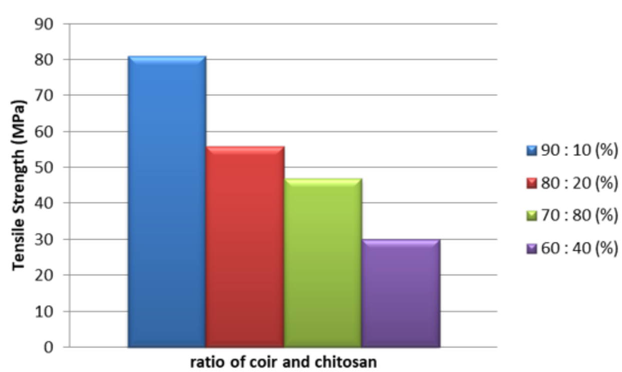

Figure 2 Graph of Tensile Test Results for Sample Formulation

Based on the graph, it can be seen that the addition of chitosan forms a composite with PLA and Coir. In Figure 2 it can be seen that the tensile strength of PLA/Coir/Chitosan with 4 samples with different variations of coir and chitosan. The differences in coir/chitosan are 90:10, 80:20, 70:80, 60:40. In this graph, the highest tensile strength value is obtained in sample 1 with a ratio of coir and chitosan (90:10) which is 80 MPa. And the lowest tensile strength value in sample 4 with variations of coir and chitosan (60:40) was 30 MPa. For coir:chitosan sample (80:20%) it has a tensile strength of 55 MPa. For coir:chitosan sample (70:80%) has a tensile strength of 48 MPa.

3.2. FUNCTIONAL GROUP ANALYSIS

At this stage of the analysis is carried out using a Fourier Transform Infrared Spectrophotometer (FTIR) Shimadzu IR Presige-21. This analysis aims to determine whether the PLA produced from the polymerization stage has met the standards due to the presence of functional group standards. In addition, this analysis also aims to determine whether the addition of coir and chitosan concentrations affects the existing functional groups and observes the possibility of reactions occurring at the processing stage which is marked by the emergence of new functional groups.

In Figure 3 below is an FT-IR graph to identify the functional groups present in sample 1 in the composition of PLA and Coir:Chitosan (90:10 (%)). In the sample there are wave peaks of 3311.78 cm-1, 2991.59 cm-1, 2279.86 cm-1, 1732.08 cm-1, 1539.20 cm-1 and 1230.58 cm-1 where respectively each of these wavelengths is a functional group N-H, C-H, N=C=O, C=O, C=C and C-O. In the formation of the synthesis of bioscaffold material, a chemical reaction occurs which forms a new compound, namely N=C=O which is an isocyanate group at the peak of the 2279.86 cm-1 group.

Figure 3

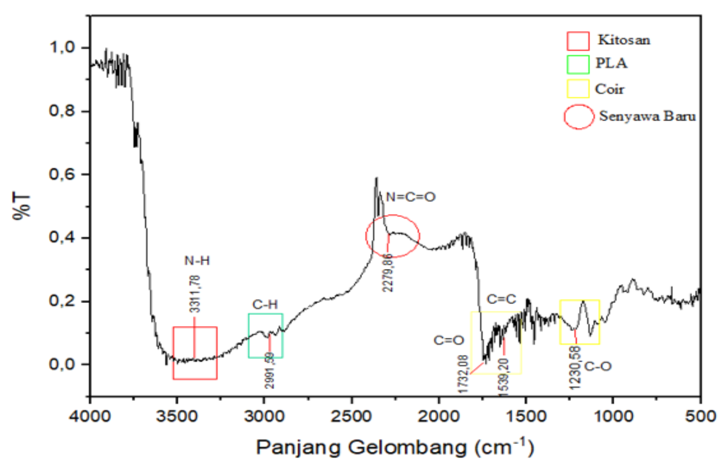

Figure 3 Graph of Functional Group Analysis of Composite Samples with Variation of Coir:Chitosan 90:10%.

These results indicate that the addition of a composite mixture of PLA/Coir/Chitosan indicates the presence of a new compound formed, namely N=C=O.

3.3. SEM (SCANNING ELECTRON MICROSCOPE) TEST

Scanning Electron Microscope is a type of electron microscope that depicts the surface of a sample through a scanning process using a high-energy beam of electrons in a raster scan pattern. Electrons interact with atoms that will make the sample generate signals and provide information about the sample's surface topography, composition, and other properties such as electrical conductivity Devi et al. (2019).

This method makes it easier for researchers to be able to observe what is happening in and around the interface between the material and the oxide layer in detail or even in-situ Sujatno (2015). The samples tested were the four research samples produced and compared.

Figure 4

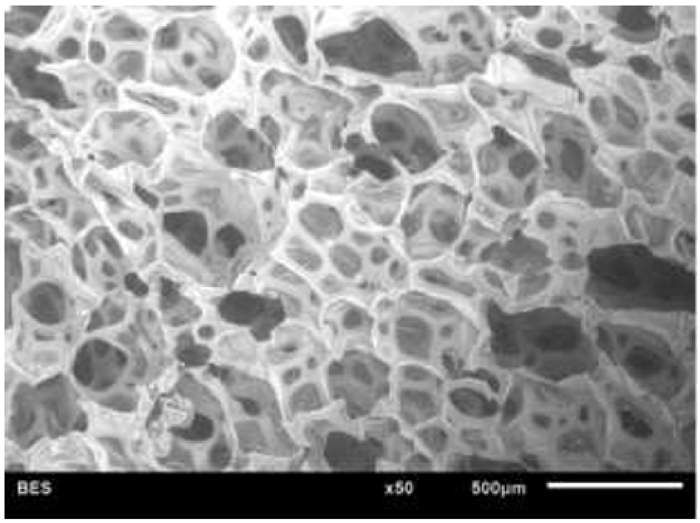

Figure 4 Morphological Characteristics 90:10 (%)

Figure 5

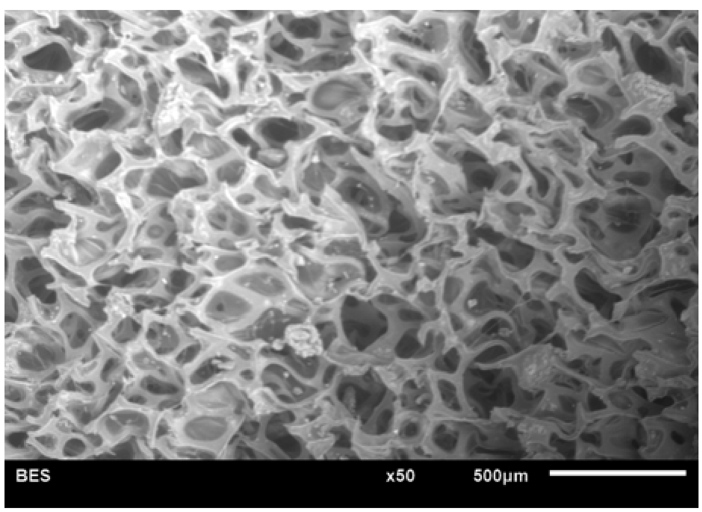

Figure 5 Morphological Characteristics 80:20 (%)

Figure 6

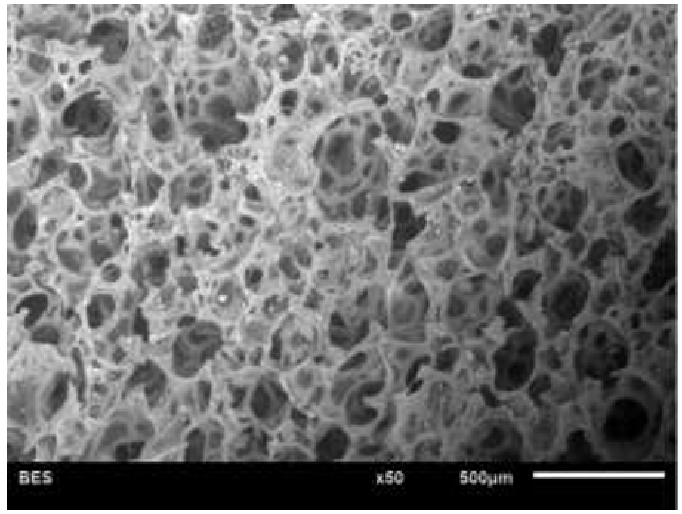

Figure 6 Morphological Characteristics 70:80 (%)

Figure 7

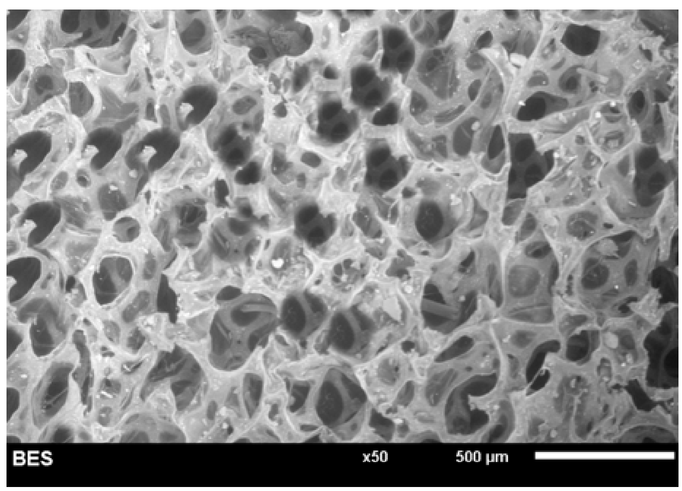

Figure 7 Morphological Characteristics 60:40 (%)

Figure 4 shows the results of SEM photos taken at a magnification of 50 times. From the picture, it can be seen that the surface of the sample is hollow, and the cracked surface is quite dominant and white spots are visible. In Figure 5 the sample is also displayed at a magnification of 50 times. The results show that the surface of the hollow composite material is cracked and there are white spots that are more clearly visible than the previous image. These white spots are chitosan that has not been spread evenly. The picture also shows the presence of white spots which indicate that the distribution of chitosan has not been uniform.

Figure 6 shows a larger hollow sample surface. This proves that the mixture of materials in this sample has met a fairly good level of homogeneity. In the morphology of this second sample, there are also no white spots, which are chitosan that has not been evenly distributed. The image also does not show any white spots in the sample morphology area at the same magnification of 50 times.

In Figure 7 is a picture of a sample with a sample mixture of 60:40 (%). It can be seen in Figure 7 that there are many white spots that are uneven and hollow cracks.

From the results of SEM photos obtained, the composition of PLA with the addition of Coir/Chitosan (90:10%) is the sample with the best morphology. This can be seen from the surface of the sample which is hollow with few cracks when compared to the other three samples. The lack of homogeneity of Nanochitosan can affect the mechanical characteristics of the analyzed samples.

4. CONCLUSION

Based on the research that has been done, it can be concluded that, PLA with the addition of Coir/Chitosan based on the test results of the tensile strength, it is found that the composite with variations of Coir/Chitosan as much as (90:10) % has the highest tensile strength value of 80 MPa. The more addition of coir that is put into a sample, it affects the level of tensile strength of a composite. While testing the results of the FT-IR research showed that the formation of new compounds from the composite mixture, where the compounds formed were N=C=O. while for the SEM (Scanning Electron Microscope) test, the mixture of materials in the coir:chitosan (70:80)% mixture has met a fairly good level of homogeneity.

CONFLICT OF INTERESTS

None.

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None.

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