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ECO-FRIENDLY NANOCOMPOSITE PLASTIC BASED ON PLA-PCL WITH FILLER CATECHIN ASARE PLACEMENT OF PETRO CHEMICAL PLASTIC

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ABSTRACT
The widespread use of plastics from petrochemical polymer materials has caused major problems for the environment, the solution requires quality biocomposites as replacement raw materials. Innovation combines Polylactid Acid (PLA) and Polycaprolactone (PCL) biopolymers with catechin filler using a mixing and melting method to get the best mixing of PLA-PCL and catechin filler using a mixing and melting method to get the best PLA-PCL mixing. PCL is combined with catechin as a filler. The composition of the PLA-PCL matrix used in this research is 2:8; 3:7 ; 5:5 ; 7:3 and 8:2, with variations in adding 0.2g of catesin filler; 0.3 grams; 0.4 grams; 0.5g and 0.6g. The melting temperature is 180^{o}C with a holding time of 20 minutes in the sample formation process on the ASTM D-638 Type I specimen which produces plastic rods/bones. Based on the results of tensile strength testing, FTIR analysis, TGA analysis and biodegradable analysis, the maximum tensile strength obtained in the PLA-PCL 8:2 composite with the addition of 0.6g filler was 46.73 Mpa. The FTIR test shows that there are C – H and C=O groups and no new functional groups are formed.

Keywords: Poly Lactid Acid (PLA), Polycaprolactone (PCl), Catechin, FTIR,TGA, Biodegradable

INTRODUCTION

Almost all Indonesian people use plastic as equipment and to fulfill their daily needs, which is strong, light and has a cheap price. In everyday life, plastic is used as *packaging* , such as drinking bottles and food containers, plastic bags and so on. The amount of this plastic is increasing day by day and cannot be renewed, so the accumulation of plastic waste is increasing and becoming a problem for humans and the environment. Besides that, petroleum raw materials are also increasingly in deficit, so there is a need for alternatives in making plastic from raw materials that are easily available in nature , environmentally friendly and at low prices [1] .

The use of plastic packaging made from petroleum is a major concern because it has a negative impact on the environment. The production of natural biopolymers is important in anticipation of reducing environmental damage. One bioplastic that has properties close to synthetic plastic is *Polylactic Acid (PLA*). *Polylactic acid* (PLA) is a type of plastic that can be produced from renewable natural materials such as starch through lactic acid fermentation and chemical polymerization. PLA is a biopolymer that is *renewable* and *biodegradable* . PLA polymer has strong, transparent and waterproof properties. The weakness is that it is stiff and has low permeability properties [2] .

To overcome this problem, several studies have been carried out to improve the properties of PLA biocomposites, namely by adding fiber material as reinforcement to improve the character of PLA polymers, such as cellulose nanowhiskers from bamboo, fibers from durian skin and hemp fiber. The addition of fiber material improves the properties of pure PLA. Apart from cellulose material, several other polymers have also been added to PLA with the aim of reducing deficiencies and improving the character of the biocomposite. Another polymer that has the potential to improve PLA characteristics is Polycaprolactone (PCL). PCL is a synthetic polymer but can be degraded well [3] .

PLA and PCL have the same properties, namely they are hydrophobic and can be degraded well. However, these two polymers have different physical properties, namely PLA is very transparent but has a stiff character and low permeability, while PCL is non-transparent and has very flexible and strong properties, so that if these two compounds are combined the resulting polymer can improve lack of properties possessed by the original polymer. In making PLA/PCL, it produces a bionanocomposite that is not mutually soluble with increasing PCL concentration, besides that there is a decrease in crystallinity in the resulting PLA/PCL mixture [4] .

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Several studies have been carried out previously to find the addition of catechin *fillers* that produce the best plastic characteristics. One of them [5] found that Catechin (Cat) was added to polyurethane (PU) based on tri-block copolymers poly(L-lactic acid) and poly(ÿ-caprolactone) (PLLA-b-PCL-b-PLLA) to improve thermal stability of the final PU composite material. The morphological, structural, mechanical and thermal properties of PU- Cat composites loaded with 1 wt%, 3 wt% and 5 wt% Paint were investigated and designed as PU-Cat1, PU-Cat3 and PU- Cat5, respectively. Homogeneous films were obtained after the solvent casting process, but amounts higher than 5 wt% used in this work could not be successfully dissolved and resulted in some structural defects as observed by scanning electron microscopy. The well-dispersed paint in PU-Cat1 and PU-Cat3 not only substantially increases the thermal stability due to the antioxidant effect of the Paint, but also allows the crystallization of PCL and PLLA Blocks in the final PU-Cat composite. In addition , PU-Cat composite materials show excellent flexibility for film production. Based on the references above, in this research, PLA/PCL and Catechin will be mixed to increase thermal stability and biodegradability by mixing polymers without reducing their quality.

METHOD

Materials

The materials used in this research consisted of 3 type ie *Polylactic Acid* (PLA), *Polycaprolactone* (PCL) and Catechin.

Methodology

2.2.1 Procedure for Making *Eco- Friendly Plastic*

Mix the PLA, PCL and chitosan polymers in specimen molds of ASTM Standard D-638 which are coated with aluminum foil using a hot press at a melting temperature of 200 ºC for 1 hour. The ratio of PLA/PCL polymer mixed with various variations of chitosan where each total mixture meets the weight of 10 grams for each sample. The biocomposite that has been formed is allowed to stand at room temperature until it solidifies completely for further testing of tensile strength, SEM, FTIR and biodegradation.

Characterization Techniques

Biodegradation Analysis

Analysis b. Purposeful degradation to estimate bioplastic decomposition time in the environment. Testing for bioplastics is carried out by planting samples in the

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soil for a certain time. Biodegradability testing is carried out by calculating the percentage of bioplastic weight loss and the rate of biodegradability.

Tensile *Strength* Analysis

analysis is a method used to test the strength of a material which is one of the mechanical characteristics of a polymer material using *a Universal Tensile Machine (UTM)* tensile tester.

Thermogravimetric analysis (TGA) analysis

In principle, this method measures the reduction in material mass when heated from room temperature to a high temperature which is usually around 900ºC with a heating rate of 20ºC/min. The TGA tool is equipped with a micro balance in it so that the sample weight can automatically be recorded and presented in a graphic display.

Results and Discussion

PLA has the ability to degrade biologically in the soil because it is obtained from renewable sources. PLA can be obtained from lactic acid which comes from sugar, starch, cellulose and glycerin from biodiesel residue. PLA is a polymer that has several uses, including for packaging, film making and the medical industry (medicine coating materials, bone implants and for surgical sutures). Apart from the advantages that PLA has, this polymer also has disadvantages, namely that PLA has hydrophobic properties which cause the degradation rate through hydrolysis of the final ester bond to take quite a long time, making it an obstacle in biomedical applications and food packaging. However, this weakness can be reduced by modifying the polymer through a *blending process* with *Polycaprolactone* (PCL). *Polycaprolactone* (PCL) is an ideal type of polymer because it is non-toxic, can be absorbed after implantation and has good mechanical properties. This polyester is resistant to water, oil, solvents and chlorine, has low viscosity and is easy to shape. Apart from that, PCL also has several disadvantages, namely that it is hydrophobic, the *biodegradation process* is a little slow and it is sensitive to micropolymer activity .

Biodegradation Test

Biodegradation Test aims to estimate the decomposition time of bioplastics in the environment. Bioplastic testing is carried out by burying samples in the ground for a certain time plastics are difficult to decompose in the soil, so

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biodegradability tests are needed to reduce the buildup of plastic waste that is difficult to decompose.

The biodegradability process can occur by hydrolysis (chemical degradation), bacteria/fungi, enzymes (enzymatic degradation), by wind and abrasion (mechanical degradation), light (photodegradation). This process can also be carried out through anaerobic or aerobic processes. In this research, biodegradation tests were carried out under aerobic conditions with the help of bacteria and fungi found in the soil. In this research, all samples were placed directly in nature and then left for the specified time.

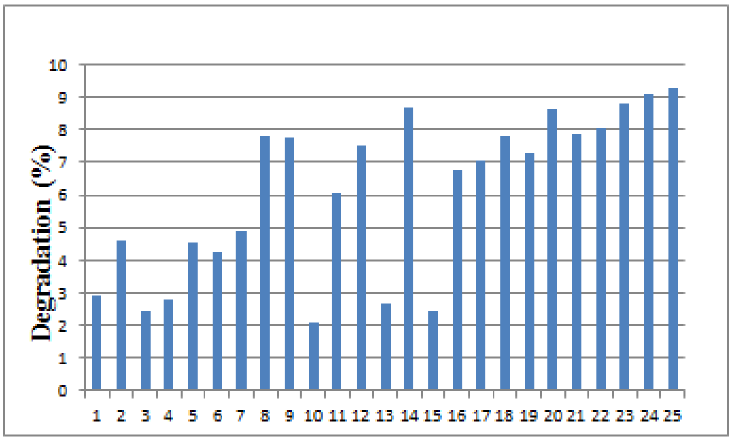

Figure 3.1 Percentage % Weight Loss for Each Sample

In the graph above, it is found that the % weight loss decreased the most, namely in the sample with a PLA/PCL composition of 8:2 with a filler composition of 0.6 g . This is influenced by the addition of filler concentration in the polymer which can increase the degradation process. In chili sauce number 14 with a catechin composition of 0.5 and a PLA/PCL ratio of 5:5, there was a fairly high weight loss, this may have been caused by the mixing process being less homogeneous, causing sample errors. The mixing process of PLA/PCL and catechin should have been carried out using an extruder, but because during the research the equipment was damaged, so it was necessary to carry out the mixing process of PLA/PCL and catechin manually.

Tensile Test Results with Universal Tensile Test Machine (UTM)

The PLA-PCL Catechin biocomposite which has been mixed according to composition variations and molded according to the ASTM D 638 type 1 standard specimen via the melting method and tested for its mechanical properties in the form of tensile strength level through the axial force provided

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by the UTM Exceed Model E43 tensile test equipment until it reaches the maximum limit until disconnected.

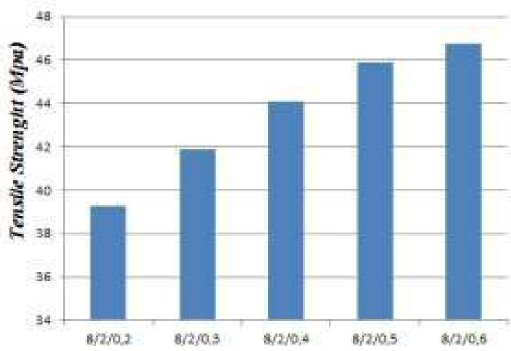

Figure 3.2 Tensile Strength

Figure 3.2 shows the *tensile strength* values of each sample at different filler concentrations. Based on this graph, it can be seen that the addition of filler shows a better increase in the tensile strength of the polymer. However, the addition of filler has a threshold, when it exceeds the threshold that can be accepted by a polymer, what happens is that the polymer becomes brittle and weak, so an ideal filler composition is needed.

tensile strength values of the five samples range from 39.26 to 46.73 Mpa. Figure 4.2 shows that *the tensile strength* of the PLA-PCL 8:2 sample with 0.6g catechin *filler* is the highest tensile test value when compared to other samples, namely 46.73Mpa. In the PLA-PCL 8:2g sample with 0.2g catesin filler, a tensile strength value of 39.26 Mpa was obtained. In the PLA-PCL 8:2 sample with 0.3g catesin filler, a tensile strength value of

41.8Mpa was obtained. In the PLA-PCL 8:2 sample with 0.4g catesin filler, a tensile strength value of 44.11 Mpa was obtained. And in the PLA-PCL 8:2 sample with 0.4g catesin filler, a tensile strength value of

45.90 Mpa was obtained. The addition of too much PCL causes a decrease in tensile strength.

3.1 ***Fourier Transform Infrared*** **(FT-IR)**

3.2 *Fourier Transform Infrared* (FT-IR)

is used to identify the type of functional group bonds possessed by materials including plastics. The purpose of FT-IR analysis on plastic film samples is to see the wavelength and characteristic peaks in the sample. This wavelength indicates the presence of a particular functional group in the sample,

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because each functional group sample has a characteristic peak that is specific to that functional group.

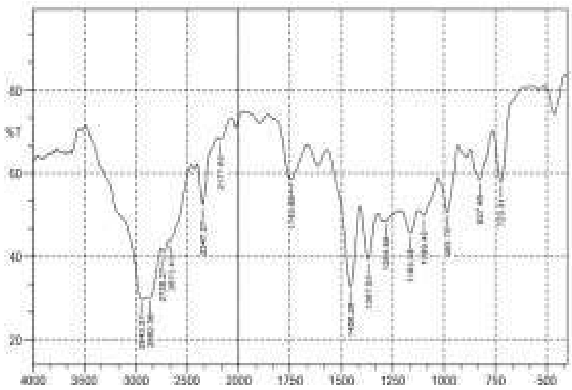

Figure 3.3 FTIR Analysis Results

The FT-IR spectrum can be shown in Figure 4.2. This analysis was carried out to identify the functional groups contained in the PLA-PCL/catechin samples produced. FT-IR is a widely used method to investigate intermolecular interactions and phase behavior between polymers. In figure 4.2 with the PLA-PCL sample, 0.2 g catechin which is the result of research that has been carried out shows the characteristic wave number areas of 2943.37 cm^{-1} , 1743.65 cm^{-1} and 1163.08 cm^{-1} which indicates the presence of the C – group H, C = O, and C – H. composite matrices. The thermal stability of fibers is a very important parameter for the processing and use of materials. The results of characterization of plastic film properties using thermogravimetric analysis can be seen in Figure 4.3. In figure 4.4 is a plot of mass decrease on the y-axis and temperature increase on the x-axis. The graph shows that all PLA-PCL samples experienced a single decomposition because the initial set and final set only occurred once. The initial set is the temperature at which the sample begins to degrade thermally and the final set is the temperature at which the sample maintains its mass from the combustion reaction. Weight loss is the amount of weight lost. This graph is a comparison of the best samples based on biodegradable test results, with the degradation temperature of the PLA/PCL catechin composite in this study ranging from 359.71 ^{o} C-575.20 ^{o} C. Where in sample 1 with a filler composition of 0.2 g catechin, onset starting at a temperature of 470.65 ^{o} C and ending at 512.91 ^{o} C with a weight loss of - 579.26%.

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The following is a graph of the TGA test results on samples that have formed composites with the addition of catechin.

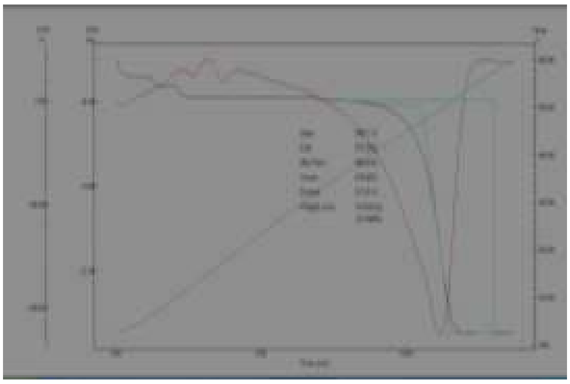

Figure 3.4 TGA Analysis

Results mass loss curves in figure 3.4 are nearly identical, indicating a one-step thermal degradation procedure . The residue content also confirmed the presence of filler, as the amount of PLA-PCL residue was found to be close to the content of the added filler. It should be noted that the active substance is organic and thermally stable under the conditions used, whereas neat PLA-PCL completely burns out. Degradable plastics are plastics that have been subjected to specified environmental conditions for a specified period of time and contain one or more steps that produce significant impacts. A change in the chemical structure of a material resulting in loss of certain properties (such as integrity, molecular mass , structure, or mechanical strength) and *fragmentation* . The degree of degradation can be divided into complete and incomplete degradation and the different degradation mechanisms can be divided into photodegradation, water degradation, thermal-oxidative degradation and biodegradation.

The results of TGA testing show that there is an increase in thermal stability so that this plastic is suitable for food packaging.

CONCLUSION

Eco-Friendly plastic is also called Biodegradable plastic or bioplastic, namely environmentally friendly plastic. Biodegradable comes from three words, namely bio which means living thing, degra which means decomposed and able means able. So, biodegradable plastic is plastic that can be biodegraded by the activity of microorganisms in the environment. The compounds resulting from polymer degradation not only produce carbon dioxide and water, but also produce other organic compounds, namely organic acids and aldehydes which are not harmful to

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the environment. Burning biodegradable plastic does not produce harmful chemical compounds. Soil quality will improve with the presence of biodegradable plastic , because it will increase the nutrients in the soil due to the decomposition of microorganisms. The main ingredient commonly used to make bioplastics is starch. Starch is a polysaccharide that can be used as the main ingredient in making biodegradable plastic. Starch is used because it is a material that can be degraded naturally into environmentally friendly compounds. In this study, the best results were obtained from samples with a PLA/PCL composition of 8:2 with a filler composition of 0.6 g from the biodegradable test results. This is influenced by the addition of filler concentration in the polymer which can increase the degradation process quickly.

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