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Mechanical and Biodegradability Properties of Bio Composite from Sago Starch and Straw Filler

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Abstract: Bio composite is a composite material with one of its component should be natural, for example using natural fiber filler or natural matrix. Composite from natural fiber is made to keep and maintain environment due to this type of composite can be degraded naturally in a shorter time compared to common composite from non-renewable polymer material. This study is aim to manufacture bio composite from sago starch with straw filler and polypropylene as plastic mixture. The addition of straw filler is expected to improve strength of the composite while still able to be degraded naturally. Mechanical properties of bio composite such as tensile strength and elongation were analyzed. The highest tensile strength value of 10.98 Mpa was obtained at the filler volume fraction of 40% to the Thermoplastic sago starch (TPS) and the ratio of TPS: Polypropylene (PP) is 1:1.5. For elongation, the highest elongation value of 15.41% was also obtained at the 40 % filler but with ratio of TPS : PP is 1 : 1. For biodegradability test, the weight loss of bio composite is influenced by the composition of filler incorporated, the higher concentration of filler then the better biodegradability rate obtained. Highest rate of biodegradability of 88.57 % for 30 days buried is obtained for 40% filler with ratio of TPS: PP is 1: 0.5.

Keywords: Bio Composite, Filler Material, Fiber Composites.

INTRODUCTION

The need for structural, lightweight and strong components has significantly increased. This has led to the development of new materials called composite materials. Composite is a combination of two or more materials, generally composed of bonding material (matrix) and reinforcing material called filler material. Fiber is one of the most commonly used as filling materials. The fibers used can be natural fibers or synthetic fibers. Besides having structural capabilities, light and strong, environmentally friendly materials are also the demands of today's technology. One material that is expected to be able to fulfill this is composite material with natural fiber filling material. The advantages of natural fibers are low density, easy to obtain, cheaper prices, environmentally friendly, and not harmful to health.

Most modern technologies require materials with a combination of extraordinary properties that cannot be achieved by common materials such as ferrous metals, ceramics and polymer materials. Composite consists of a main material (matrix) and a type of reinforcement which is added to increase the strength and stiffness of the matrix. This reinforcement is usually in the form of fiber. Composite is widely developed today because it is able to combine several properties of different characteristics into new properties and in accordance with the planned design. Composites are classified into three types, namely, fiber composite materials (Fiber Composites), particle composite materials (Particulate Composites) and layer composite materials (Laminates Composites).

Various problems on plastic waste and natural fiber waste have encouraged technology development to use environmentally friendly product nowadays. Plastic has been derived from several local starches such as cassava and sago. With certain modification, it has been proven to have similar characteristic with

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conventional plastic. To improve its characteristics, it can be reinforced with natural fiber such as straw, rice husks, wood husk, and cotton to become bio composite. Bio composites made from natural fiber has many advantages such as biodegradable, improved mechanical properties such as strength and stiffness. In this study, we use straw to produce bio composite from modified sago thermoplastic reacted in-situ. At present the utilization of straw is less efficient, so that a lot of straw waste from rice farming. Straw can be used as a composite filler material; it is available in huge quantity, cheap and environmentally friendly. The mechanical and biodegradability properties of bio composite is studied to analyze the effect of natural fiber addition.

RELATED RESEARCH

Starch-based plastic mixtures have poor mechanical properties such as low tensile strength, stiffness, low elongation at break, low humidity stability and release small amounts of plasticizing molecules from starch matrix Modification of starch, use of compatibilizer, reinforcement, and improvement of process conditions, are expected to make starch as a conventional plastic substitution material. (Zhang et al. 2007). Films made from cellulose derivatives and a number of thermoplastic resins in the form of sheets and tubes can be used as wrappers, bags and covers (Wiwik et al, 2012). Films from a mixture of starch and plasticizers can be used as packaging, but must meet certain mechanical properties.

Several studies in the field of plastic using starch and polyurethane have been carried out. Ferrer et al., 2008 characterizes polyuerethane networks derived from plant-based polyols comparing them to synthetic polyueretan networks. The results obtained are polyuerethane-based plant polyols having lower tensile strength in accordance with the increase in polyurethane molecular weight (Ferrer et al, 2008). Transparent film mixture from PU based on castor oil and p-phenylene diamine soy protein (PDSP) was prepared by Liu et al 2008. Miscibility, morphology and properties of mixed films were tested by FTIR, DSC, DMA, SEM, adsorption moisture, thermal degradation and tensile tests. Both components are suitable for a large number of ratios as a result of strong hydrogen bonds or chemical cross-links that occur between PU and PDSP. Elongation, thermal stability, and water resistance of PU/PDSP films increase with the addition of PU (Liu et al, 2008). Lu et al., 2005 developed PU from rapeseed oil-based polyols, and then used it to modify glycerol plasticized starch (PS) to overcome the disadvantages of starch, namely poor mechanical properties and water sensitivity. The results showed that plasticized glycerol starch could be mixed with rapeseed oil-based PU at PU content below 20% and phase separation occurred when PU content increased. Addition of PU into the starch matrix also increases film resistance to water (Lu et al, 2005).

Paryanto (2011), analyze of the effect of the volume fraction of the filler fibers of pineapple leaves on polyester resin matrix composites on tensile strength, showed the results that fibers which have a fiber orientation in the direction of the composite length so that when the composite given the force it it will be able to withstand this force and be passed on by the fiber before the composite will break, but the relationship between variations in the volume of the short fiber particle fraction to the tensile strength of the composite shows that the tensile strength of the composite with short random fiber particles decreases with increasing volume of short random fiber fractions. . This is due to the imperfect bond between fiber fillers and matrices along with the addition of fiber filler volume in the composite which causes many voids.

Nurhidayah Ninis (2016) analyze the effect of palm leaf fibers with polyester resin matrix on composite elongation showed that at 30% fiber volume variation will give 20.5% elongation value and at 45 % fiber volume will result 18.33% elongation value.This is because the resulting strain decreases as the fiber volume fraction increases. The decrease in strain is caused by the addition of the amount of fiber in the composite which will further block the polymer molecules from moving from one place to another resulting in an earlier failure when given the load.

PROPOSED METHOD

Preparation of Polymer Fibre.

Straw is cut into small pieces and mashed using a blender. Furthermore, it sieved to homogeny into 50 mesh size.

Preparation of Thermoplastic Starch

Straw, sago powder and water are weighed according to the set up composition and mixed together. The mixture then heated and stirred until become gelatin at a temperature of 70^{o}C for 25 minutes. MDI (Methylene Di-Isocyanate) and polyol was added with a predetermined ratio to modify the thermoplastic starch (TPS) by in-situ mechanism. Glycerol as plasticizer was added 10% and stirred rigorously until homogeneous. The homogeneous mixture was dried using an oven at 80⁰C for 24 hours. The dried mixture will form like a crust and cut into smaller sizes.

Preparation of Bio Composite

Polypropylene (PP) was heated at 110⁰C until melted and mix with thermoplastic starch until homogeny. The mixture was then printed in the glass casting to form a film and leave for 24 hours to dry it in an oven. When it dried the film was taken out and ready to be test specimen.

RESEARCH METHODOLOGY

This research method included the stages of producing starch thermoplastic and bio composite and stage of analysis. The analysis done was to measure mechanical property (tensile and elongation) of bio composite to understand its strength. Biodegradability property was checked by burying sample 30 cm deep in the ground and observes the natural degradation process by counting the biodegradability rate by weighing the sample every 7 days for a month.

RESULTS AND DISCUSSIONS

Mechanical test was done using Tensile and elongation test, while biodegradability was done to see the time required by bio composite to degrade naturally in the soil.

The tensile strength of a material is the tensile strength of the test material to accept the load without being damaged or broken. The value of tensile strength does not depend on the size of the material but because on the type of material. Other factors contribute to the strength such as the presence of impurities in the material, temperature and humidity of the test environment, and the preparation of specimens. Elongation is a change in maximum length before the bio composite is cut off. Elongation percentage presented the ability of bio composite to stretch to the maximum.

Mechanical testing of straw bio composite was carried out using the Torsee's Electronic System test machine. The measurement results are carried out to determine the tensile strength and elongation. Tensile strength testing was carried out in accordance with ASTM-D 638-03 standard.

The relationship between filler and matrix (TPS) on bio composite tensile strength can be seen in graph 1 below:

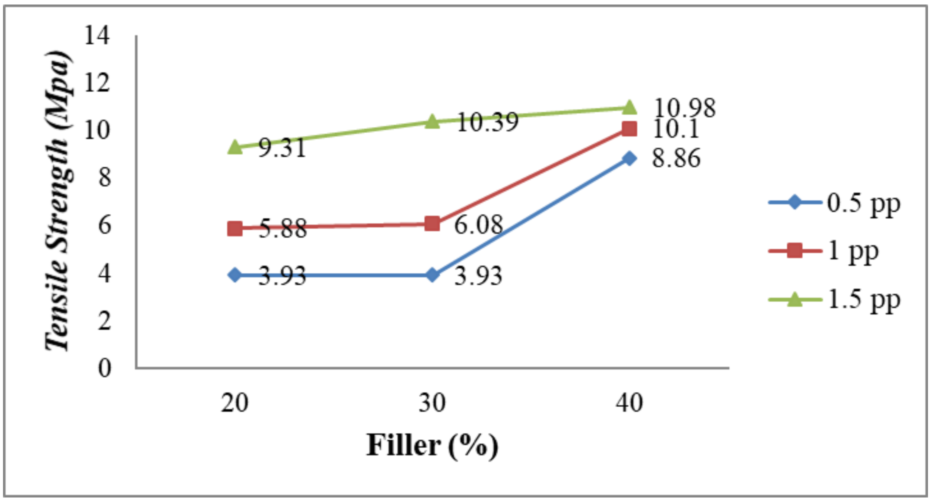


Fig.1: Relation between Tensile Strength of Bio Composite with different ratio of Filler and Matrix.

The increase in tensile strength is influenced by the binding power between the filler with matrix and the addition of the volume of the straw fill fraction on the composite. The more filler used, tensile strength is increased. The addition of Polypropylene as well as has contributed to increasing of tensile strength where the higher tensile strength is observed at 40% filler and 1.5 PP blending ration.

The research result conducted by Wijang and Dody in 2008, title as The Effect of IR 64 Straw Powder Use as UPRs Composite Filler on Tensile Strength in Terms of Weight Fraction Variations (Wijang and Dody, 2008). They found out that higher filler content will decrease the tensile strength. The result somehow slightly different.

Elongation percentage is the length increase of a test material due to the withdrawal load until just before experiencing fracture. The relationship of straw filler composition on elongation percentage can be seen in graph 2 below:

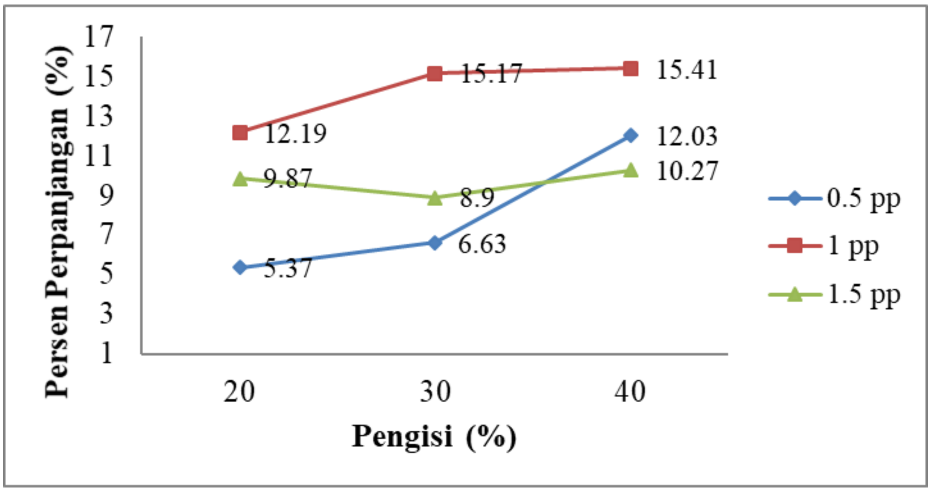
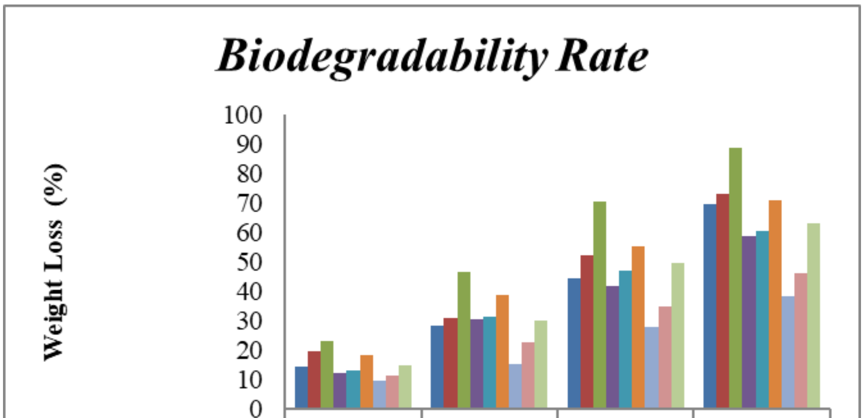


Fig.2: Relation between elongation percentages with Filler composition

From Figure 2, it can be seen that more filler used will resulting in higher percentage of elongation measured, and vice versa. Filler has an effect to give flexibility for bio composite. However, excessive amount will decrease the tensile strength.

Graph 3 shown relationship of Weight Loss (%) against time for several filler composition on bio composite.



	7	14	21	28
Filler 20% 1 : 0.5	14.21	28.43	44.12	69.61
Filler 30% 1: 0.5	19.63	30.84	52.34	72.89
Filler 40% 1: 0.5	22.86	46.67	70.47	88.57
Filler 20% 1 : 1	12.36	30.34	41.57	58.43
Filler 30% 1 : 1	12.84	31.19	46.78	60.55
Filler 40% 1 : 1	18.35	38.53	55.05	70.64
Filler 20% 1 : 1.5	9.52	15.24	27.62	38.09
Filler 30% 1 : 1.5	11.32	22.64	34.91	46.23
Filler 40% 1 : 1.5	14.56	30.09	49.51	63.11

Fig.3: Bio Composite Weight Loss (%) Against Time (Day)

On Figure 3, it can be seen that the weight loss rate (%) of bio composite is affected by filler. More filler will contribute to higher weight loss rate. While addition of polypropylene has also reduced the weight loss rate, therefore bio composite will take more time to damage and degradation. In this study, bio composite with 40% filler with Ratio of TPS and PP is 1: 0.5 has higher lower degradation rate due to lower amount of PP inside. This is because the microbes that help the degradation process in the soil, namely pseudomous microbes and bacillus will break the polymer chain into its monomers. Therefore there is a synergistic performance between the activities of several microbes.

CONCLUSION

From the results of the study some conclusions can be drawn, among others: the highest tensile strength value is found at 40% filler with mixing ratio between TPS and PP is 1: 1.5 of 10.98 Mpa. The more fillers used, the higher the tensile strength obtained. The highest elongation value was obtained at 40% filler with mixing ratio between TPS and PP is 1: 1 at 15.41%. The more fillers used, the higher percent elongation obtained. Bio composite with 40% filler at ratio TPS : PP is 1: 0.5 is decomposed faster 88 % percent on the 28 day of biodegradability test.

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