STUDY OF BIOCOMPOSITES FROM RICE STRAW AND POLYLACTIC ACID

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***Abstract*— Natural fiber reinforced polylactic acid based biocomposites are broadly considered by the researchers to compete with non-renewable petroleum based products. In this study, the biodegradable composites which are the polylactic acid, PLA and rice straw, RS were prepared by using heated two roll-mill at 180°C. Mechanical properties showed that the tensile strength and elongation at break, E_b decreased with the increment of RS and Young's modulus. The TGA results confirmed that thermal stability of PLA with RS composites decreased with the increasing of RS.**

Keywords—Polylactic acid, rice straw, tensile test, thermogravimetric analysis (TGA), biocomposites

I. INTRODUCTION

In recent years, there has been growing awareness of various industries in renewable plant materials. The most commonly proposed method of biomass waste management is just its incineration as a renewable source. Up till now, the biomass is also valuable source of cellulose and more particular, cellulose fibers. At present, over half of the 70 million tons of different product manufactured every year is derived from oil based materials [1]. These non-degradable polymers are now believed as a serious environmental problem and become huge challenge to waste management [2]. So, there is an growing number of biopolymers used to substitute the present polymers such as polylactid acid (PLA), poly(hydroxybutyrate) (PHB) and poly(butylenes adipate-co-terephthalate) (PBAT) which are capable to act as biodegradation material [3]. Biodegradation materials can be prepared by the mixture of biodegradable polymers and natural fibers. It can be utilized in sutures, controlled-released drug and surgical implants [4].

Using straw and other agricultural residues for preparation of the composites materials has becomes the focus of the world. But discarded tires, formaldehyde resins, polymers will be the main matrix [5] and the main reinforcement for the composite will be crushed materials like rice straw powder, rice husk powder or extracted straw powder [6].

II. EXPERIMENTAL

A. Materials

RS fiber was obtained from Perlis, Malaysia were dried in oven at 70°C for 3 hours to remove moisture before use. PLA in pellet form was obtained from Biopla Products Factory with the density of 1.24 g/cm^3.

B. Preparation of composites

PLA and RS were mixed by using heated two roll-mill at temperature 180°C. Before pressing, the RS were dried in the vacuum oven for 24 hours. The ratio of RS was varied from 5% to 25%.

C. Tensile Test

Tensile test specimens were cut according to ASTM D638 [7,8]. At least five samples of the composites were test at a rate of 5mm^{-1} at the room temperature. Average values of tensile strength, elongation at break E_b and Young's modulus were determined [9]

D. Thermogravimetric Analysis

Thermogravimetric analysis (TGA) was performed to record the weight loss as function of temperature. Samples were heated from 30°C-700°C with the heating rate of 10°C/min under flow of nitrogen to prevent oxidation [10].

III. RESULTS AND DISCUSSION

A. Tensile Properties

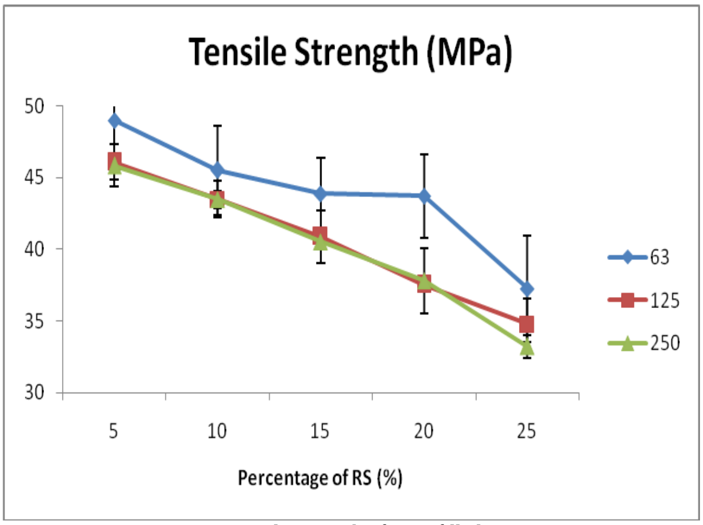

Fig. 1: Tensile strength of PLA filled RS

Fig. 1 represents tensile strength of PLA with RS. The increasing size and ratio of RS vary from 63µm to 125µm and 5% to 25% respectively had reduced the tensile strength. The reason was attributed to the low surface area of the RS contact with the surface of PLA. Besides, this also might due to RS could not dispersed well in the matrix which induced poor interfacial adhesion between PLA and RS that reduced the strength [10].

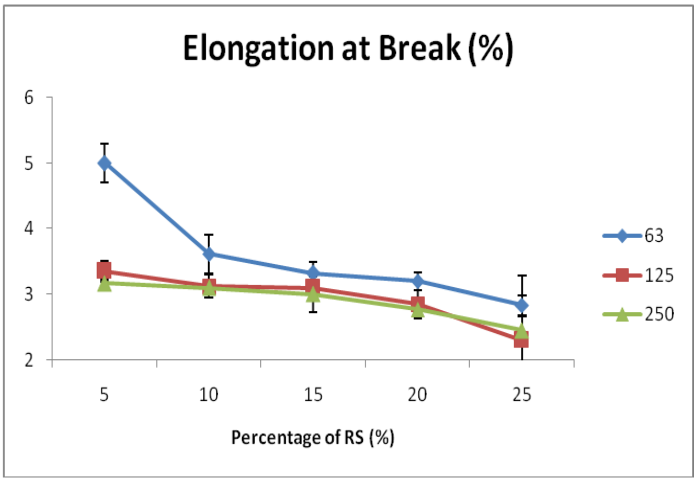

Fig. 2: Elongation at break of PLA filled RS

Fig. 2 illustrated the E_b of PLA with RS. The result shown the E_b decreased gradually with the increasing of ratio and size of the RS. This might due to poor interfacial adhesion between PLA and RS. The effectiveness in the interfacial adhesion of the phases can be attributed to the different chemical structures and degree of functional group affects the degree of interaction between phases of the composites [9]. Besides, it is because the compatibility between hydrophobic PLA and hydrophilic RS. This observation is in agreement with the work done by Sam et al. [12].

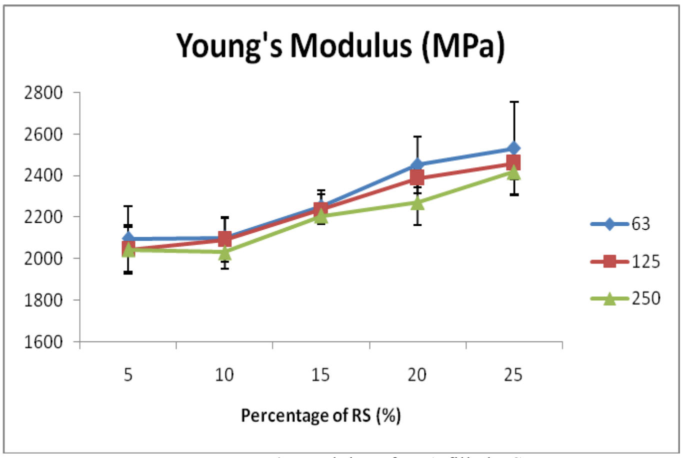

Fig. 3: Young's Modulus of PLA filled RS

Sam et al. [12], has concluded in their study that the increase of Young's modulus and reduction in E_b are proportional to the crosslink density. An increase of Young's modulus in natural agricultural fiber is a common since the fiber is known to act as rigid filler that increases the stiffness [13]. Besides, this is because increasing of RS loading in PLA matrix had increased the interaction between the filler which also known as filler-filler interaction.

B. Thermogravimetric Analysis (TGA)

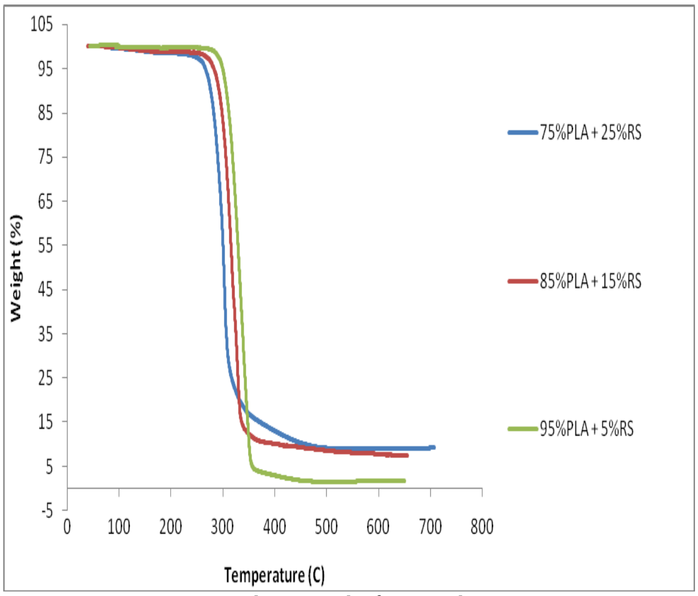

Fig. 4: Thermograph of PLA with RS

Table 1: Thermal degradation of RS with PLA

Sample	$T_{-5\%}$ (°C)	$T_{-30\%}$ (°C)
5% RS + 95% PLA	101.03	201.20
15% RS + 85% PLA	81.74	203.09
25% RS + 75% PLA	73.41	219.74

Thermal degradation of PLA with RS composites has been explored in terms of weight loss by TGA carried in air as shown in *Fig. 4*. The residual weight is accessible in graphical form as a function of temperature for PLA with RS. Table 1 shows the investigation of thermal degradation RS with PLA. The $T_{-5\%}$ (^oC) and $T_{-30\%}$ (^oC) values represent initial degration at 5% sample weight loss and middle degradation at 30% sample weight loss, respectively. The table illustrated that the thermal stability of RS with PLA decreases with the increasing of PLA. A significant drop in $T_{-5\%}$ (^oC) can be studied on going from 5% to 25% of spear in RS with PLA. This result is harmony with the study of tensile properties. This is because the incorporation of RS loading up to 25% caused a significant reduction in the interaction between RS and PLA. Besides, this could be due to the low thermal stability of the filler which is the RS [14].

IV. CONCLUSION

Biocomposites consisting of PLA and RS shows promising mechanical properties. The results indicate that the tensile strength and E_b of PLA with RS decreased with the increasing ratio of RS, whereas the Young's modulus increased. The weight loss of the composites at $T_{-5\%}$ increased with increasing of RS whereas the weight loss has increased at $T_{-30\%}$. This study shows that the improvement of mechanical and thermal properties for PLA.

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