Eco Bioplastics Packaging LDPE/Corn Stalk Powder with Eco Degradant: The Effect of Eco Degradant on Mechanical Properties

Azimah Binti Ismail[1*], Rokayah A Rashid[1], and Riduwan Zakaria[1]

*[1]Politeknik Sultan Abdul Halim Muadzam Shah,
Bandar Darulaman, Jitra,Kedah, Malaysia*

ABSTRACT

This study investigated contain of Eco Bioplastics Packaging LDPE/Corn Stalk Powder with Eco degradant on tensile properties, as well as the morphology of Light Density Polyethylene/Corn Stalk Powder (LPDE/CSP) biocomposites. It was found that increment of CSP content decreased tensile strength. The dispersion and interfacial adhesion between CS filler and thermoplastic emerged as significant factors that affected the tensile properties of biocomposites system. In order to improve interfacial adhesion, incorporation of Eco degradant into LDPE/CSP composites is recommended. The Scanning Electron Microscopy (SEM) analysis displayed improvements to the interfacial adhesion between LDPE as matrix and corn stalk powder (CSP) filler with the presence of Eco degradant.

INTRODUCTION

Reinforced plastics composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. Recently, there have been an increasing interest in the completely biodegradable composites reinforced with natural fibers, because they are biodegradable, renewable and environmentally friendly, notwithstanding their use in low cost applications [1]. Many researchers have come out with the same definition of bio composite, it involves matrix phase that consists of thermoset and thermoplastic groups and its phase filler is made out of natural resources for example agro wastes such as jute, sisal, kenaf, pineapple leaf, bagasse, coir and many more [2]. Biocomposites materials can be broadly defined as composite materials consisting of natural filler and a fossil fuel based polymer (polyethylene and polypropylene) or biopolymer [3]. Biocomposites consists of a biodegradable polymer as matrix material and natural fibers as reinforcing element, in theirs studied [4]. Studies on bio composite have drawn interest among other researchers and it has been an active research subject in this decade [4]. This is because nowadays, people are getting more concern for environment and in future, it is expected that the world is going to face a major oil crisis. Apart from that, rules and environmental campaigns set up by the government have also attracted researchers to conduct this study [5]. Plastic matrix in this studied from group thermoplastics. Low density polyethylene resins are re-emerging as a valuable product family, combining superior clarity with a stiffness and density favored by converters for down gauging. Low density polyethylene (LDPE) is commonly used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic bags for computer components, and various molded laboratory equipment [6]. This choice is made after considering that 80% of our daily lives involved the usage of plastic bag, plastic container and water container because they are made of low-density polyethylene resin. Corn Stalk (CS), the subject of the present study, is a waste product of corn. Hence, corn stalk can be

* Corresponding Author: *azimahcomposites@gmail.com*

acquired for industrial purposes without any additional cost. Currently, waste corn stalk is often used as animal food.

In addition, corn stalk is also used in pulp and paper industry. In order to make use of harness waste, we also can use corn stalk. Therefore, this study chooses corn stalk as natural filler in biocomposites and indirectly it will increase the value of corn stalk waste [7]. This is to overcome environmental issues and the use of waste product from farming to save production cost. The compatibility problem may be due to the fact that the polyolefin is non-polar and hydrophobic, where the natural polymer, which is a lignocellulosic material, is polar due to the –OH groups in cellulose [8]. This causes poor adhesion and prevents the reinforcing filler from acting effectively in the composite. Improvement in the compatibility between these two materials may help in obtaining good properties of these composites. Thus, a number of studies have been carried out on surface modification or treatment of filler in order to solve these problems. A compatibilizing agent or coupling agent is used in the studies in order to reduce the hydrophilicity of the filler. This happens because LDPE is made out of petroleum (oil) while corn stalk is from plant, which makes it water absorbent. Thus, to overcome this situation, coupling agent is used to improve its compatibility [2].

EXPERIMENTAL

Materials

The Light Density Polyethylene grade LDF200YZ (film extrusion general purpose) was supplied by Titan Chemicals Corp. Bhd. The corn stalk was obtained from Kodiang Plantations, Kedah and cleaned manually. After cleaned, the corn stalk was crushed and grinded into powder. The corn stalk powder (CSP) was dried at 80^{o}C for 24 hours. The average particle size of the CSP was 29.96μm, by using Malvern Particle Size Analyzer Instrument. Behn Meyer Polymer Sdn Bhd is the supplier for the Eco degradant. Eco degradant PD 04 is a Polyolefins based Controlled Degradation Masterbatch. Polyolefins which are incorporated with Eco degradant PD 04 would decrease gradually to lower molecular weights. As a result, they turn out to be brittle, disintegrated and eventually dissolved by microorganism and revert to Carbon dioxide (CO2), water (H2O) which is the basic elements and no dangerous residues in biomass involved. It has been tested by Hong Kong Productivity Council and confirmed to meet the requirement of food grade polyethylene material which is in accordance with FDA 21 CFR 177.1520.

Preparation of Biocomposites

Brabender Plastograph mixer Model EC PLUS was employed to prepare the LDPE/CS biocomposites at 160^{o}C with a rotor speed of 50 rpm. By using mixing chamber also, the composites LDPE/CS with Eco degradant, the LDPE was mixed for two minutes until it was melted completely. After two minutes, CS powder and Eco degradant were added and continued for six minute. A compression moulding machine (Model GT 7014A) was used to compress the biocomposites into a tensile bar. In accordance to ASTM D638, a type IV tensile bar with 1 mm thickness was used as reference. The compression procedure involved preheating at 160^{o}C for 4 minutes, followed by compression for 1 minute, and subsequent cooling under pressure for 5 minutes. The formulation of without Eco degradant and with Eco degradant LDPE/CS biocomposites with different filler loading was shown in Table 1.

Table 1 Formulation of LDPE/CS Biocomposites

Materials	LDPE/CS without Eco Degradant	LDPE/CS with Eco Degradant
LDPE(php)	100	100
CS (php)	0,10,20,30,40	0,10,20,30,40
Eco degradant (php)*	-	3

*3php from weight LDPE.

Tensile Testing

Instron Machine (Model 5569) was applied to carry out the tensile test by adhering to ASTM D638. The test was conducted with a crosshead speed of 50 mm/min at room temperature. For each composition, five identical samples of tensile properties were measured and the average values for tensile strength, elongation at break, and Young's Modulus had been reported.

Morphology Analysis

The instrument applied for morphology study in this experiment was a Scanning Electron Microscope (SEM) (Model JEOL JSM-6460LA), in order to observe the dispersion of CSP as filler in the LDPE matrix, as we ll as the bonding between LDPE as matrix and filler. The fracture ends surface of the specimen was placed on an aluminum stub and the sputter was coated with a thin layer of Palladium (Pd) to avoid electrostatic effect during the examination.

RESULTS

Strength

Figure 1 shows the effect of filler loading on tensile strength of LDPE/CS biocomposites with as well as without eco-degradant. According to the results provided the tensile strength of LDPE/CS biocomposites without eco-degradant has decreased when the CS content is increased. The decreased of tensile strength with the increasing CS content explained that the weak interfacial adhesion as well as poor dispersion between filler and polymer matrix. However, the biocomposites with eco degradant showed higher tensile strength compared to biocomposites without eco degradant. By having eco degradant, it has improved the tensile properties as well as developed the interfacial interaction between low density polyethylene and also corn stalk powder. Resulting in better wettability, dispersion and orientation of the corn stalk and low density polyethylene matrix may have clarified the effectiveness of eco degradant in increasing the strength of the biocomposites. Besides, the founding of strong interaction between the eco-degradant and the fillers can be promoted through the presence of hydroxyl group on the surface of the corn stalk powder. Meanwhile, the polymer matrix would be interacted with the nonpolar part of eco degradant. Furthermore, with the increasing of mechanical properties exhibits that eco degradant has successfully utilized as an additive in LDPE/CS biocomposites. This trend is reliable with the previous study [9]. They reported that the tensile strength has been decreased when the wood loading was increased.

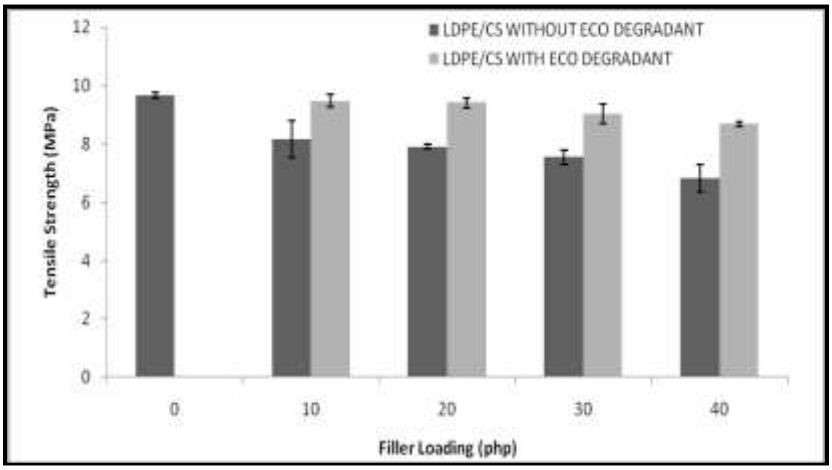

Figure 1. The effect of filler loading on tensile strength of LDPE/CS biocomposites with and without eco degradant.

Elongation at Break

The effect of filler loading on elongation at break of LDPE/CS bicomposites with and without eco degradant is explained in figure 2. The elongation at break has decreased progressively when the filler loading is increased. The decreasing trend on elongation at break could be seen in both biocomposites. However, tensile strength has been improved but elongation at break has been reduced due to the presence of eco degradant as additive. It was noticeable regarding the improvement of adhesion of biocomposites between filler and matrix. At similar loading, elongations at break biocomposites without eco degradant is lower than biocomposites with eco degradant. The adding of eco degradant has increased the ductility of biocomposites and was clearly marked for biocomposites with eco degradant because of adhesion between filler and LDPE matrix restricts deformation capacity of matrix in the elastic zone in addition to the plastic zone.

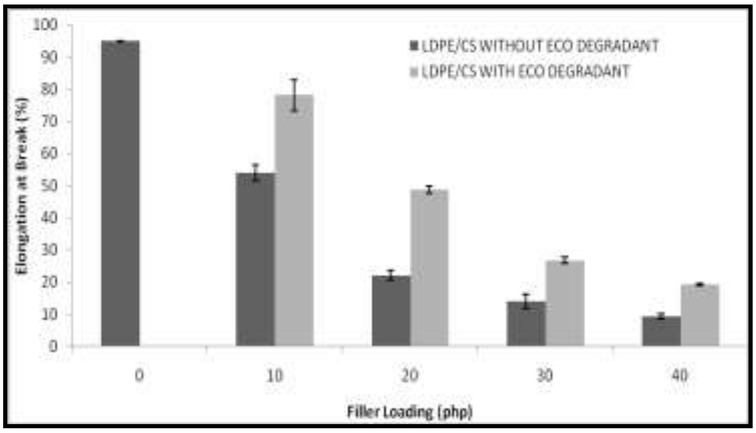

Figure 2. The effect of filler loading on elongation at break of LDPE/CS biocomposites with and without eco-degradant.

Young's Modulus

Figure 3 shows Young's modulus of LDPE/CS biocomposites with and without eco degradant has been affected by filler loading where it has increased with the increasing of CS content. Young's modulus is used as a sign of the relative stiffness of composites. The increased in Young's modulus with the increasing in CS content is predicted since the addition of filler has increased the stiffness of the composites. However, at same filler loading the Young's modulus of the biocomposites with eco degradant is lower compared to biocomposites without eco degradant. With the existence of eco degradant, the stiffness of LDPE/CS biocomposites has been improved, while the polymer chain mobility appears with better filler-matrix interaction.

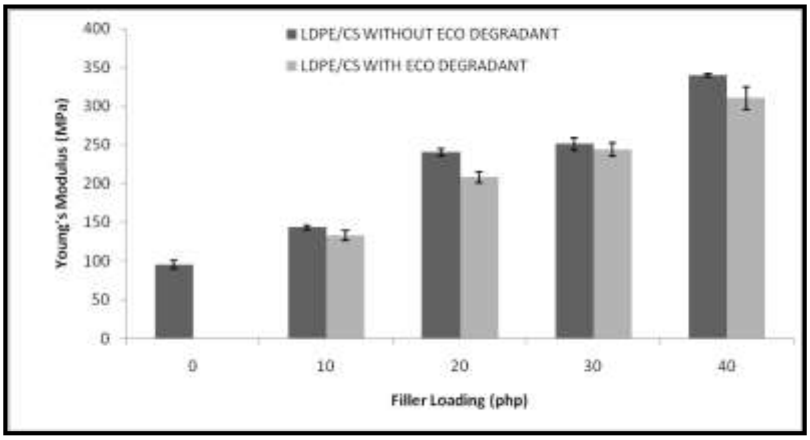

Figure 3. The effect of filler loading on Young's modulus of LDPE/CS biocomposites with and without eco-degradant.

Morphology Study

The micrograph of tensile fracture surface of LDPE/CS biocomposites without eco degradant at 20 and 40 php were shown in Figures 4 and 5, respectively. The micrograph of bicomposites without eco degradant show poor wetting of corn stalk in LDPE matrix. From Figures 6 and 7, it can be concluded that with the presence of eco degradant, the corn stalk was well dispersed in LDPE matrix. Both micrographs also show the rough surfaces while the matrix was used to coat filler. This indicates the filler and the matrix are compatible to each other. The adhesion between fiber and matrix was improved as provided by the eco degradant. Therefore, these outcomes provide as clear evidence that the compatibility between filler and matrix was enhanced extensively when reacted to the eco degradant.

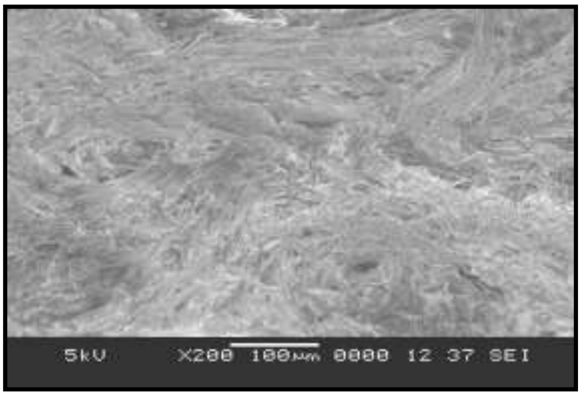

Figure 4. SEM micrograph of tensile fracture surface of LDPE/CS biocomposites without eco degradant (20php) at magnification 200X.

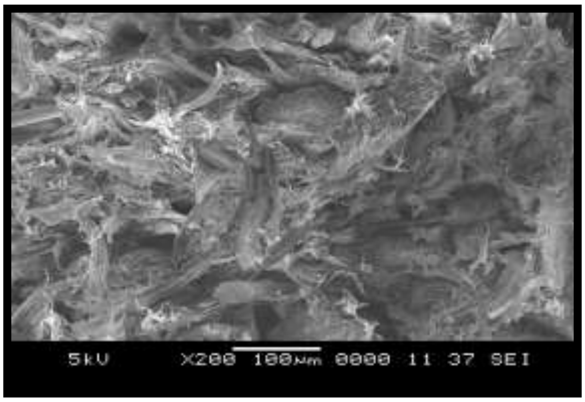

Figure 5. SEM micrograph of tensile fracture surface of LDPE/CS biocomposites without eco degradant (40php) at magnification 200X.

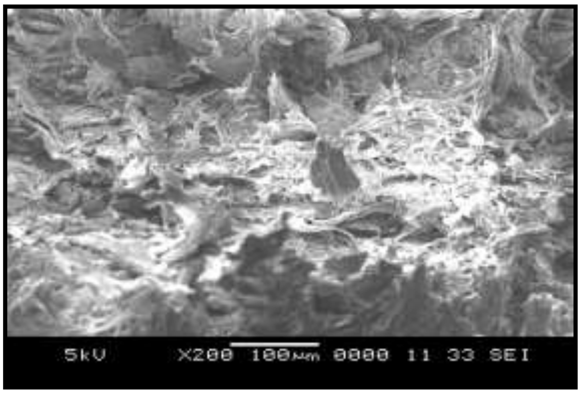

Figure 6. SEM of tensile fracture surface of treated LDPE/CS biocomposites with eco degradant (20 php) at magnification 200X.

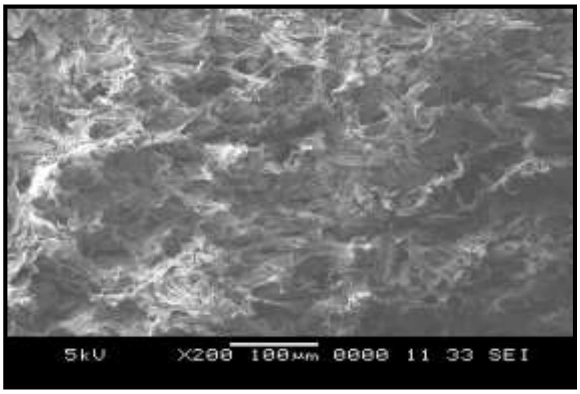

Figure 7. SEM of tensile fracture surface of treated LDPE/CS biocomposites with eco degradant (40 php) at magnification 200X.

CONCLUSION

The presence of eco-degradant enhanced the tensile strength, elongation at break, and crystallinity of biocomposites with eco-degradant. The morphology of biocomposites with eco-degradant showed the plasticity behavior. The utilization of CS in LDPE has given positive effect on the tensile properties of biocomposites.

REFERENCES

Mohanthy, S., Verma, S.K., Nayak S.K. (2006). Dynamic mechanical and thermal properties of MAPE treated jute/HDPE composites. *Compos Sci Technol*, 66, 538-47.

Abdul Khalil, H.P.S., SriAprilia, N.A., Bhat, A.H., Jawaid, M., Paridah, M.T., Rudi, D. (2013). A Jatropha biomass as renewable materials for biocomposites and its applications. *Renewable and Sustainable Energy Reviews,* 22, 667-685.

John, M.J., & Thomas, S. (2008). Biofibers and biocomposites. Carbohydr. Poly., 71, 343-364.

Mohanty, A.K., Mubarak, A., Khan & Hinrichsen, G. (2000). Surface modification of Jute and its influence on performance of biodegradble jute-fabric/Biopol composites. *Composites Science and Technology*, 60, 1115-1124.

Pizzi, A., Kueny, R., Lecoanet, F., Massetau, B., Carpentiar, D., Krebs, A., Loiseau, F., Molini, S., Ragoubi, M. (2009). High resin content natural matrix natural fibre biocomposites. *Industrial Crops and Products*, 30, 235-240.

H.S. Yang, M.P. Wolcott, H.S. Kim, H.J. Kim, Effect of different compatibilizing agents on the mechanical properties of lignocellulosic material filled polyethylene bio-composites, Compos. *Struct*. 79 (2007) 369– 375.

Yeng, C.M., Salmah, H., Sam, S.T. (2013). Modified Corn Cob filled chitosan biocomposites films. Polym.*Plast.Technol.Eng*, 52, (14), 1496-1502.

Maya Jacob John, Rajesh Anandjiwala, D. (2009). Chemical modification of flax reinforced polypropylene composites. *Composites: Part A*, 40, 442-448.

Kaci, M., Djidejelli, H., Boukkerrou, A., Zaidi, L. (2007). Effect of wood filler treatment and EBAGMA compatibilizer on morphology and mechanical properties of low density polyethylene/olive husk flour composites. *Express Polymer Letters*, 1, 467-473