Eco Bioplastics Packaging LDPE/Corn Stalk Powder with Coconut Oil Coupling Agent (COCA): Influence of Coupling Agent on Mechanical Properties

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ABSTRACT

This study investigated contain of Eco Bioplastics Packaging LDPE/Corn Stalk Powder with Coconut Oil Coupling Agent (COCA) 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 Coconut Oil Coupling Agent (COCA) 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 Coconut Oil Coupling Agent (COCA).

INTRODUCTION

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 [1]. Biocomposites materials can be broadly defined as composite materials consisting of natural filler and a fossil fuel based polymer (polyethylene and polypropylene) or biopolymer [2]. Biocomposites consists of a biodegradable polymer as matrix material and natural fibers as reinforcing element, in theirs studied [3]. 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 [3].

In this study, a research is done on a matrix phase of thermoplastic that is low density polyethylene. 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. This situation is also common in other fields such as industrial, farming and automotive whereby the same plastic of low density polyethylene being used. Corn stalks (CS) are one of the most widely cultivated farms across the globe. The other parts of the corn become wastes after the harvesting season, particularly the corn cob [5]. The utilization of CS has high potential to be incorporated into value product within the plastic industry as natural filler. This is to overcome environmental issues and the use of waste product from farming to save production cost. Natural fibers offer substantial advantages for biocomposites, except that polar fibers have inherently low compatibility with non-polar polymer matrices, especially hydrocarbon matrices, such as polypropylene (PP) and polyethylene (PE).

Compatibility between composite components, this is one of the criteria to produce a strong composite. The compatibility between strengthening material and matrix allows the interaction to take place and results in good surface bonding. In this study, the compatibility between matrix phase, LDPE is hydrophobic and fiber phase made of farming waste, corn stalk is hydrophilic. 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 80oC for 24 hours. The average particle size of the CSP was 29.96µm, by using Malvern Particle Size Analyzer Instrument. The COCA was produce using virgin coconut oil and ethylene diamine.

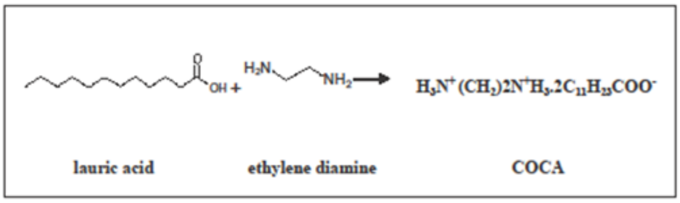

Figure 1. Schematic reaction of COCA.

Sample Biocomposites

BrabenderPlastograph mixer Model EC PLUS was employed to prepare the LDPE/CS biocomposites at 160oC with a rotor speed of 50 rpm. By using mixing chamber also, the composites LDPE/CS with COCA, the LDPE was mixed for two minutes until it was melted completely. After two minutes, CS powder and COCA 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 160oC for 4 minutes, followed by compression for 1 minute, and subsequent cooling under pressure for 5 minutes. The formulation of without COCA and with COCA LDPE/CS biocomposites with different filler loading was shown in Table 1.

Table 1 Formulation of LDPE/CS Biocomposites

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

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 AND DISCUSSION

Tensile Properties

Figure 2 shows the effect of filler loading on tensile strength of without COCA and with COCA LDPE/CS biocomposites. The tensile strength of LDPE/CS biocomposites was decreased when the filler loading increased. It happens because of the weak interfacial adhesion, and poor dispersion between filler and polymer matrix. The tensile strength of with COCA LDPE/CS is higher compared to without COCA LDPE/CS biocomposites. This behavior can be attributed to present of strong interfacial adhesion and better dispersion between filler and polymer matrix with addition COCA. The formation of hydrogen bonding between the COCA and hydroxyl groups of corn stalk have created an interaction of better fillers - matrix. The effectiveness of COCA in increasing the strength of the composites may explain by greater wet ability, dispersion and orientation of the CS and LDPE matrix. The same finding also found on palm oil fatty acid (POFA) as compatibilizing agent on bentonite filled polypropylene composites [7]. The addition of POFA has improved the interaction between bentonite and polypropylene to become more effective thus increasing the tensile strength of the composites.

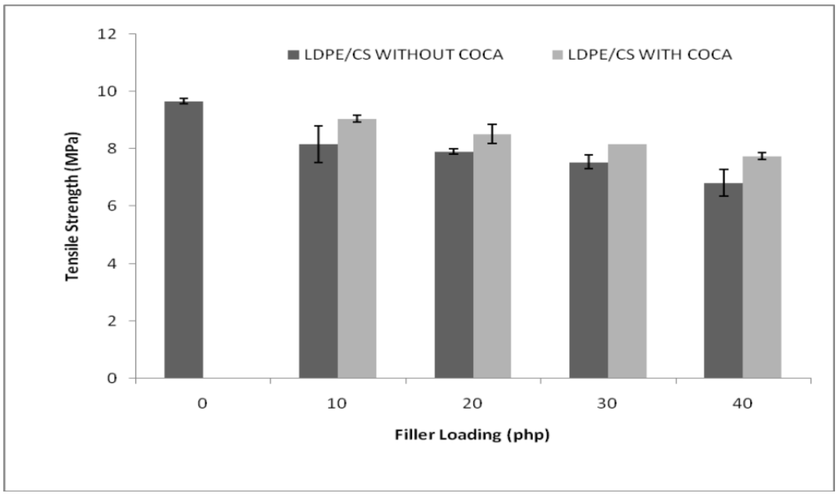

Figure 2. The effect of filler loading on tensile strength of without COCA and with COCALDPE/CS biocomposites.

Figure 3 shows that, the elongation at break of LDPE/CS biocomposites decreased in the company of filler loading. The elongation at break of both biocomposites show decreasing trend with CS loading increased, due to the presence of COCA which have good dispersion and interfacial region between filler and matrix are formed. At similar filler loading, elongations at break of without COCA LDPE/CS biocomposites lower than with COCA biocomposites and presence of COCA shows plasticizer properties of LDPE/CS with COCA biocomposites.

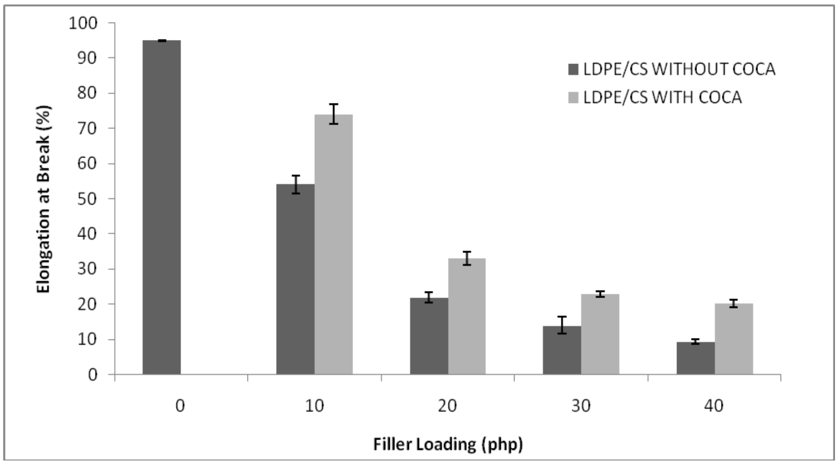

Figure 3. The effect of filler loading on elongation at break off without COCA andwith COCA LDPE/CS biocomposite.

The Young's modulus of without COCA and with COCA LDPE/CS biocomposites was increasing with the increasing of filler loading is shown in Figure 4. The composites without COCA in Young's modulus have increased when filler loading is increased. It has been identified that the modulus of composites can be increased when the filler has higher stiffness than matrix. In the Young's modulus, the biocomposites without COCA LDPE/CS is higher than the biocomposites with COCA LDPE/CS even though with the similar loading. These results indicate that the efficiency of COCA in improving plasticizers of LDPE/CS composites, while the polymer chain mobility inherent by the better filler-matrix interaction. The application of coupling agent in polymer composites was used to overcome the dispersion pattern and to enhance the mechanical strength of composites by improving adhesion across the interface [8].

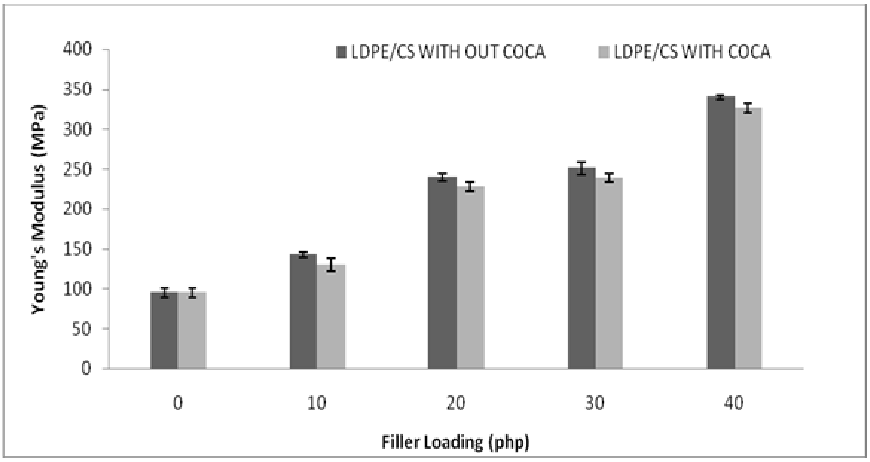

Figure 4. The effect of filler loading on Young's modulus of without COCA and with COCA LDPE/CS biocomposites.

Morphology Study

The micrograph of tensile fracture surface of LDPE/CS biocomposites without COCA at 20 and 40 php were shown in Figures 5 and 6, respectively. The micrograph of bicomposites without COCA show poor wetting of corn stalk in LDPE matrix. The micrograph of tensile fracture surface for LDPE/CS biocomposites with COCA at 20 and 40 php of filler loading are shown in Figure 7 and 8. It seems that both micrographs show filler dispersion and adhesion is better in LDPE matrix. The fiber-matrix adhesion was enhanced due to the chemical connections between fiber and matrix supplied by the COCA. Therefore, these results proved the compatibility between filler and matrix was considerably can be improved when react to the COCA.

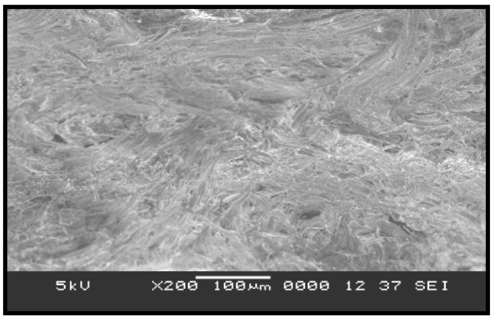

Figure 5. SEM micrograph of tensile fracture surface of LDPE/CS biocomposites without COCA (20php) at magnification 200X.

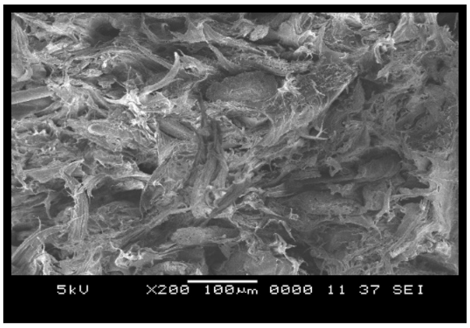

Figure 6. SEM micrograph of tensile fracture surface of LDPE/CS biocomposites without COCA (40php) at magnification 200X.

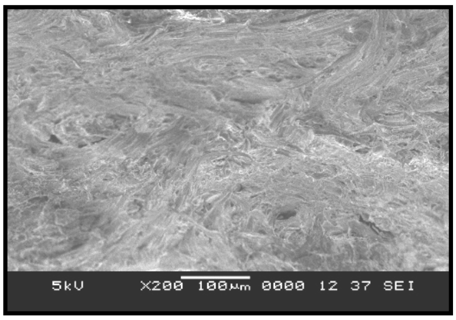

Figure 7. SEM micrograph of tensile fracture surface LDPE/CS biocomposites with COCA (20php) at magnification 200X.

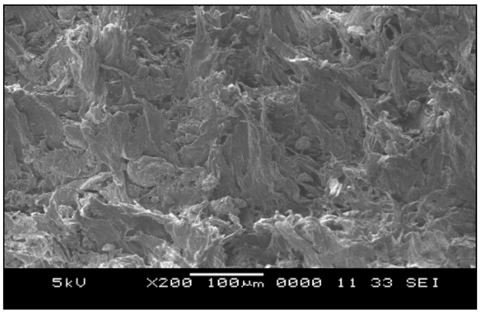

Figure 8. SEM micrograph of tensile fracture surface of LDPE/CS biocomposites with COCA (40php) at magnification 200X.

CONCLUSION (Equations and mathematics)

The effect of COCA as a coupling agent in LDPE/CS biocomposites has increased the tensile strength and elongation at break but decreased the Young's Modulus. The presence of COCA showed better dispersion, wettability of CS in LDPE matrix and morphology of biocomposites with COCA showed ductility behavior.

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