Compatibilization of Corn Stalk Filled Low Density Polyethylene Biocomposites: Influence on Mechanical Properties

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ABSTRACT

This research investigates the effect of corn stalk content and compatibilizer on tensile properties and morphology of Low Density Polyethylene (LDPE)/Corn Stalk (CS) biocomposites. It was found that the increasing of corn stalk content, tensile strength and elongation at break decreased while Young's modulus increased. The dispersion and interfacial adhesion between the corn stalk filler and thermoplastic were important factors affecting the tensile properties of composites system. In order to improve the compatibility and interfacial adhesion, the incorporation of compatibilizer, Maleic Anhydride Polyethylene (MAPE) into LDPE/CS composites is recommended. The addition of MAPE has enhanced tensile properties and interfacial interaction between corn stalk and LDPE biocomposites was proven by SEM study.

INTRODUCTION

Biodegradable polymers have been a subject of interest for many years because of their potential to protect the environment by reducing non-biodegradable synthetic plastic waste [1]. Biodegradation involves enzymatic and chemical degradation by living microorganisms [2]. Based on this study, plastic matrix which comes from a group of polyethylene thermoplastics has been used broadly in daily life [3]. Polyethylene (PE), the largest volume plastic used in packaging, is the worst offender and is highly resistant to biodegradation. Although starch has been studied as a filler in plastics for about 40 years, degradable starch–plastic composites with good mechanical properties only came into existence in the mid 1970's [4]. However, the degradation of these composites has been of serious concern to environmentalists because of the slow biodegradation of polyethylene. This has prompted the incorporation of starch to serve as a bio degrading and the use of biodegradation aids such as photo oxidants to accelerate the biodegradation process. Despite that, the molecular weight of PE decreases only after a very long period [5]. Agriculture is an important sector in Malaysian economy. Traditionally, agricultural materials have been shipped away for processing, or disposed of post-harvest. Diversification of the industry is crucial in encouraging economic stability and growth. Value added processing would help in agricultural diversification. There are a lot of industrial and waste materials that are currently being thrown everywhere and one of them is agriculture biomaterials. Big amount of them occur universally as waste materials of industrial processing and other operations. They occur in various processed forms, such as pulp sludge from the manufacture of paper, commonly known as clarifier sludge, wood, sugar cane, bagasse pith, grass, coarse grass, sisal, pineapple, coir and jute [6] Corn Stalk (CS), the subject of the present study, is a waste product of corn. Hence, corn stalk can be 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

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corn stalk waste [7]. This is to overcome environmental issues and the use of waste product from farming to save production cost. Interfacial adhesions between the natural reinforcing filler and matrix polymers, is the most important issue associated with these composites. The compatibility problem may be due to the fact that the polyolefin is non-polar and hydrophobic, whereas the natural polymer, which is a lignocellulosic material, is polar due to the –OH groups in cellulose. This results in poor adhesion and prevents the reinforcing filler from acting effectively in the composite. The good properties of these composites can be obtained by improving the compatibility between these two materials. In order to solve these problems, studies have been performed on surface modification or treatment of filler using a compatibilizing agent or coupling agent in order to reduce the hydrophilicity of the filler [8]. In this study was focus to investigate the effect of filler loading of CS and Maleic Anhydride Polyethylene (MAPE) as compatibilizer into LDPE/CS bicomposites on mechanical properties, and morphology.

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 Maleic Anhydride Polyethylene (MAPE) was supplied by Aldrich.

Preparation of Biocomposites

The LDPE/CS biocomposites was prepared by using Brabender Plastograph mixer Model EC PLUS at temperature 160°C and rotor speed of 50 rpm LDPE and MAPE was charged into mixing chamber for two minute until it completely melts. After two minute, CS powder was added and mixing continued for six minutes. The total mixing time was eight minutes. The biocomposites was compressed into tensile bar by using compression molding machine model GT 7014A. Tensile bar was reference to ASTM D638 tensile bar type IV with 1mm thickness. The compression procedure involved preheating at 160°C for 4 minute follow by compressing for 1 minute and subsequent cooling under pressure for five minutes. The similar procedure was done for PLA/Cs with MAPE. The formulation of uncompatibilized and compatibilized LDPE/CS biocomposites with different filler loading was shown in Table 1.

Table 1 Formulation of LDPE/CS Biocomposites

Materials	LDPE/CS Uncompatibilized	LDPE/CS Compatibilized
LDPE(php)	100	100
CS (php)	0,10,20,30,40	0,10,20,30,40
MAPE(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

Scanning Electron Microscope (SEM) model JEOL JSM-6460LA was used to examine the dispersion of corn stalk in LDPE matrix. The fracture ends of the specimen were mounted on an aluminum stub and sputter coated with a thin layers of palladium electrostatic charging during examination.

RESULTS

Strength

Figure 1 shows the effect of filler loading on tensile strength of uncompatibilized and compatibilized LDPE/CS biocomposites. The tensile strength of LDPE/CS biocomposites was decreased with the increasing of filler loading. This occurs because the weak interfacial adhesion, and poor dispersion between filler and polymer matrix. The tensile strength of compatibilized LDPE/CS higher compared to uncompatibilized LDPE/CSbiocomposites. This behavior can be attributed to present of strong interfacial adhesion and better dispersion between filler and polymer matrix with addition MAPE. The better fillers- matrix interaction was derived from the formation of hydrogen bonding between the MAPE and hydroxyl groups of corn stalk. The mechanical properties of uncompatibilized and compatibilized LDPE/lignocellulosics biocomposites. The results showed that the tensile strength has clearly increased as the filler content was increased for compatibilized biocomposites. These results showed the beneficial effect of the copolymer and by using MAPE, it improved the tensile strength owing to better stress transfer from the matrix to filler [9].

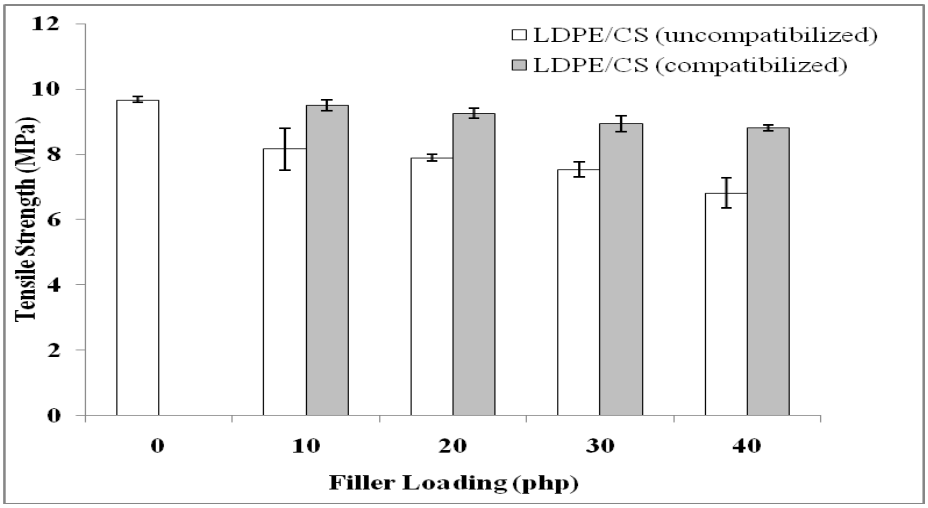

Figure 1. The effect of filler loading on tensile strength of uncompatibilized and compatibilized LDPE/CS biocomposites.

Elongation at Break

Figure 2 shows that, the elongation at break of LDPE/CS biocomposites decreased with filler loading. The elongation at break of both biocomposites show decreasing trend with CS loading increased, due to weaker interfacial region between filler and matrix areformed. At similar filler loading, elongation at break of compatibilized LDPE/CS biocomposites lower than uncompatibilized biocomposites. The brittleness and stiffness of LDPE/CS biocomposites increased with increasing filler loading and the elongation at break decreased due to the reduction of the polymer chain mobility. Research study on a recycled polyethylene/chitosan composites effect of polyethylene graft maleic anhydride (MAPE), the result showed that at similar filler loading, the elongation at break of compatibilized RPE/chitosan composites is lower compared to uncompatibilized RPE/chitosan composites [10].

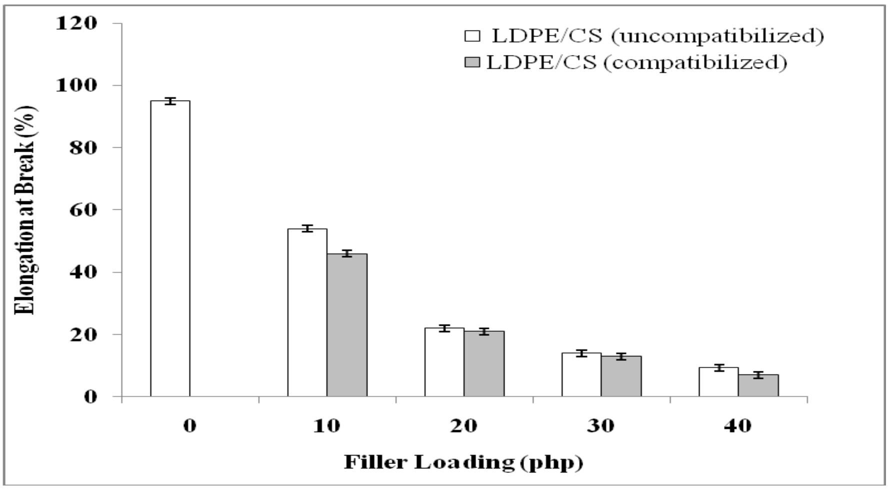

Figure 2. The effect of filler loading on elongation at break of uncompatibilized and compatibilized LDPE/CS biocomposites.

Young's Modulus

The Young's modulus of uncompatibilized and compatibilized LDPE/CS biocomposites was increasing with the increasing of filler loading is shown in Figure 3. The Young's modulus 0f uncompatibilized composites increased with increasing filler loading. It is known that filler which has higher stiffness than matrix can increase the modulus of composites. At similar filler loading, the Young's modulus of the compatibilized LDPE/CS biocomposites higher than uncompatibilized LDPE/CS biocomposites. The present of MAPE enhanced the stiffness of LDPE/CS biocomposites, while the polymer chain mobility inherent by the better filler-matrix interaction. The application of compatibilizer in polymer composites was used to overcome the dispersion pattern and to enhance the mechanical strength of composites by improving adhesion across the interface. The problem of adhesion and bonding strength between rice husk flour and polypropylene using MAPP as compatibilizing agents. They found tensile strength and modulus were both increased [11].

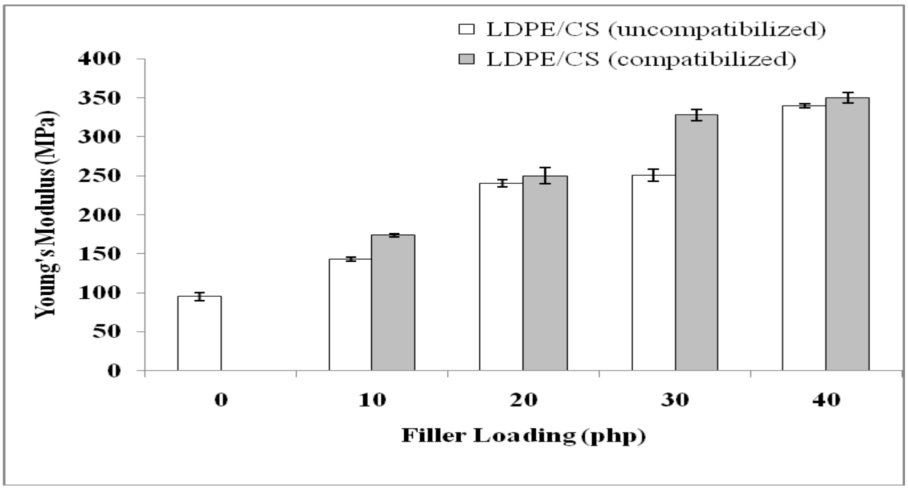

Figure 3. The effect of filler loading on Young's modulus of uncompatibilized and compatibilized LDPE/CS biocomposites.

Morphology Study

The micrograph of tensile fracture surface of uncompatibilized LDPE/CS biocomposites at 20 and 40 php were shown in Figures 4 and 5, respectively. The micrograph of uncompatibilized bicomposites show poor wetting of corn stalk in LDPE matrix. It can see that the bonding at interface of CS and LDPE matrix and CS pull out from LDPE surface, indicates a low adhesion between CS and LDPE matrix. Figures 6 and 7 exhibit that compatibilized biocomposites better interfacial adhesion between filler and matrix and less CS pull out from matrix.

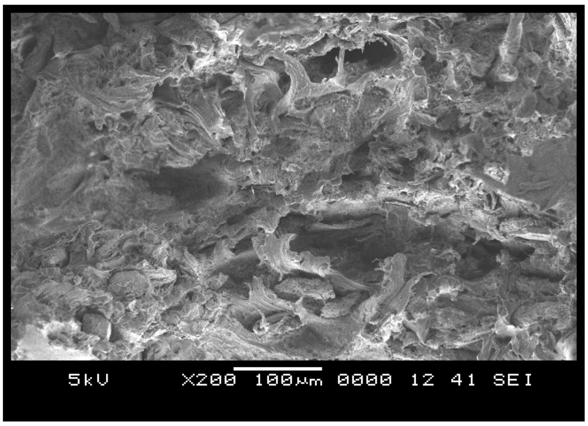

Figure 4. SEM micrograph of tensile fracture surface of uncompatibilized LDPE/CS biocomposites with MAPE (20php) at magnification 200X.

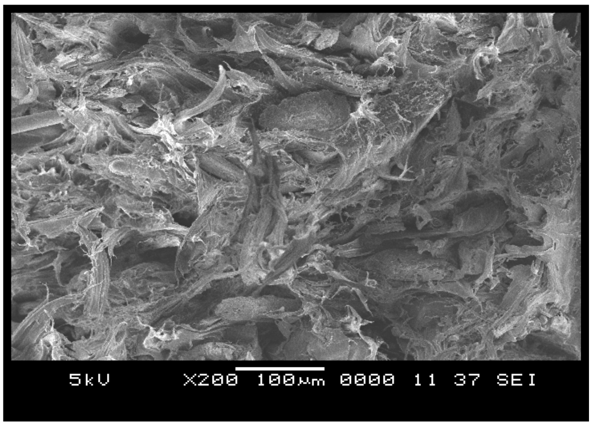

Figure 5. SEM micrograph of tensile fracture surface of uncompatibilized LDPE/CS biocomposites with MAPE (40php) at magnification 200X.

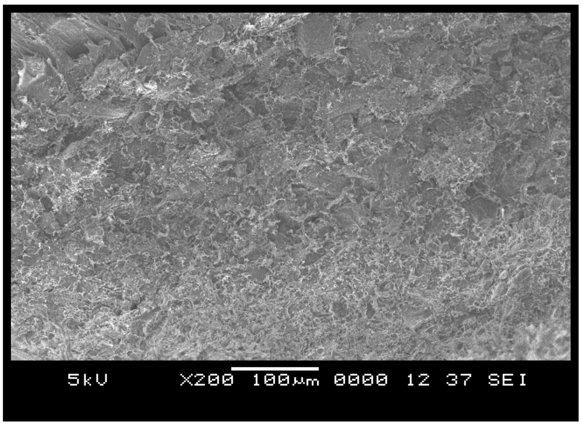

Figure 6. SEM micrograph of tensile fracture surface of compatibilized LDPE/CS biocomposites with MAPE (20php) at magnification 200X.

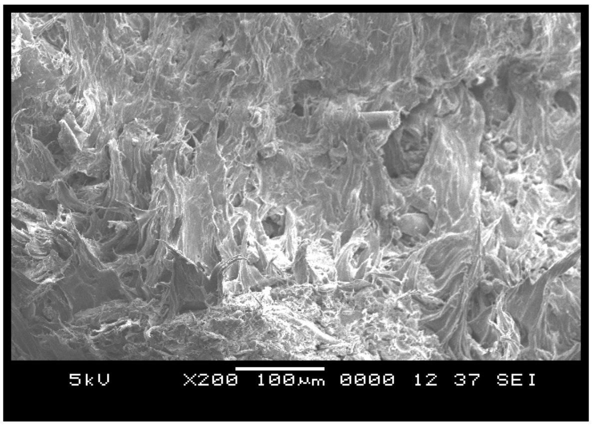

Figure 7. SEM micrograph of tensile fracture surface of compatibilized LDPE/CS biocomposites with MAPE (40php) at magnification 200X.

CONCLUSION

The compatibility between corn stalk (CS) and LDPE matrix was improved by the addition of MAPE as a compatibilizer. The tensile strength and Young's modulus of compatibilized LDPE/CS biocomposites higher than uncompatibilized biocomposites. SEM studies indicate that the interfacial adhesion between CS and LDPE matrix improved with presence of MAPE.

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