Eco Bioplastics Packaging LDPE/Corn Stalk Powder with Maleic Anhydride Polyethylene (MAPE): Influence of Compatibiliser on Mechanical Properties

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ABSTRACT

This study investigated contain of Eco Bioplastics Packaging LDPE/Corn Stalk Powder with Maleic Anhydride Polyethylene (MAPE) 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 Maleic Anhydride Polyethylene (MAPE) 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 Maleic Anhydride Polyethylene (MAPE).

INTRODUCTION

The function of biocomposites in a variety of applications has been domineering for a long time now, mainly due to their specific strength and modulus [1]. Biocomposites are bound to become the most widely applied commercial material in near time with the vast potential of these underutilized renewable materials, especially in the non-food-based market within the agriculture domain [2]. Light density polyethylene (LDPE) resin is widely known for its benefits. Its combination of superior clarity with high stiffness and density has been highly sought by converters for down-gauging. The LDPE is commonly used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic bags for computer components, and packaging applications [3].

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 [4]. The utilization of CS has high potential to be incorporated into value product within the plastic industry as natural filler. 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). This incompatibility poses problems in composite processing and material properties. In order to address this incompatibility issue, a number of physical and chemical methods have been proposed to modify these natural fibers to increase their compatibility aspect [5].

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EXPERIMENTAL METHOD

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

Brabender Plastograph mixer Model EC PLUS was employed to prepare the LDPE/CS biocomposites at 160oC with a rotor speed of 50 rpm. Both LDPE and MAPE were charged into a mixing chamber. It took two minutes for the first LDPE batch to be charged into the mixing chamber until it completely melted. The CSP was added into the mixing chamber after two minutes and the mixing was continued for another six minutes. The total mixing time was eight minutes. 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 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

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 well 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 & DISCUSSION

Strength

Figure 1 displays the tensile strength of uncompatibilised and compatibilised LDPE/CS biocomposites. As a result, the tensile strength for compatibilised LDPE/CS was higher than that for uncompatibilised LDPE/CS biocomposites. The higher tensile strength for that compatibilised was recorded at 10 php and was almost similar to the result obtained for virgin LDPE. This behaviour is attributable to the presence of strong interfacial adhesion, as well as better dispersion between CS filler and polymer matrix with the addition of maleic anhydride polyethylene (MAPE). MAPE effectively functioned as a compatibiliser due to its better stress propagation that improved the compatibility and wetting of the matrix polymer. MAPE also efficiently enhanced the filler matrix bonding due to the formation of covalent linkages and hydrogen bonding between maleic anhydride and hydroxyl group of CS filler. Similarly, reported the enhanced tensile properties in biocomposite of thermoplastic rice starch (TPRS)/LDPE upon adding MAPE [6]. They further explained that the increased tensile strength was due to the bonding between the polyethylene part of MAPE and LDPE, as well as due to the strong ester linkage that formed between the maleic anhydride part of MAPE and hydrophilic rice starch.

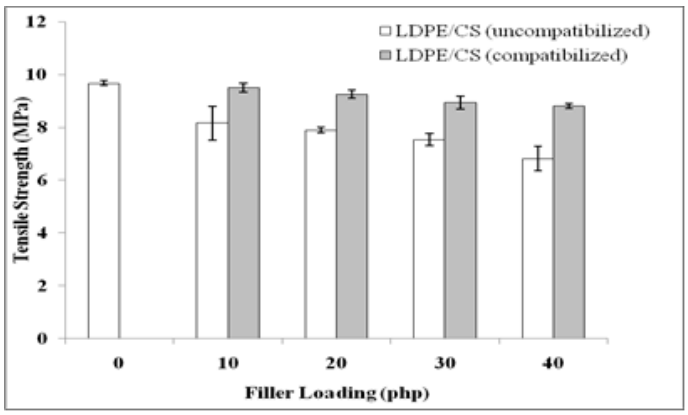

Figure 1. The effect of filler loading on tensile strength of uncompatibilised and compatibilised LDPE/CS biocomposites.

Elongation at Break

Figure 2 showcases the elongation at break of both uncompatibilised and compatibilised LDPE/CS biocomposites. Both biocomposites displayed a decreasing trend of elongation at break with increment of CS loading. At similar CS loading, the elongation at break of compatibilised LDPE/CS was lower than that for uncompatibilised composites. Hence, the presence of MAPE indicates improved adhesion at the interface between CS and LDPE. The decreased elongation at break observed for all the biocomposites suggests a good degree of interfacial compatibility between filler and matrix. In assessing the effect of polyethylene graft maleic anhydride (MAPE) on recycled polyethylene (RPE)/chitosan composites, Salmah et al., reported that at similar filler loading, the elongation at break of compatibilised RPE/chitosan composites was lower than those uncompatibilised [7].

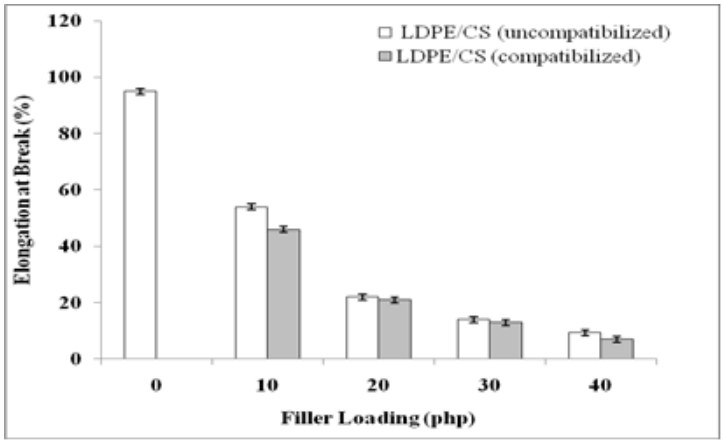

Figure 2. The effect of filler loading on elongation at break of uncompatibilised and compatibilised LDPE/CS biocomposites.

Young's Modulus

Figure 3 shows the Young's modulus of both uncompatibilised and compatibilised LDPE/CS biocomposites. The Young's modulus of both biocomposites increased as the CS loading was increased. The Young's modulus of the compatibilised LDPE/CS biocomposites was higher than those uncompatibilised. The presence of MAPE further enhanced the stiffness of the LDPE/CS biocomposites. MAPE was incorporated to address issue related to dispersion, apart from enhancing the Young's modulus of biocomposites by improving adhesion cross the interface. Lei et al., who examined the effect of MAPE on recycled high-density polyethylene (RHDPE)/bagasse and RHDPE/wood composites, reported significant improvement in the bonding between the matrix and fibre, thus enhancing the tensile modulus of the biocomposites [8].

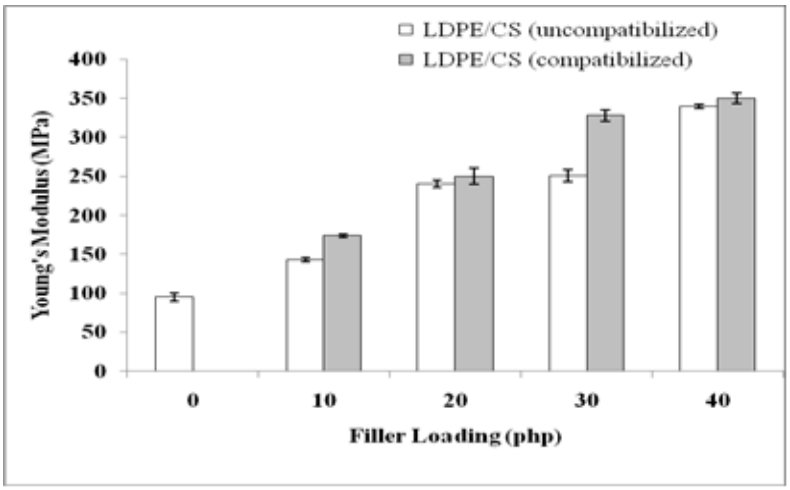

Figure 3. The effect of filler loading on Young's modulus of uncompatibilised and compatibilised LDPE/CS biocomposites.

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.

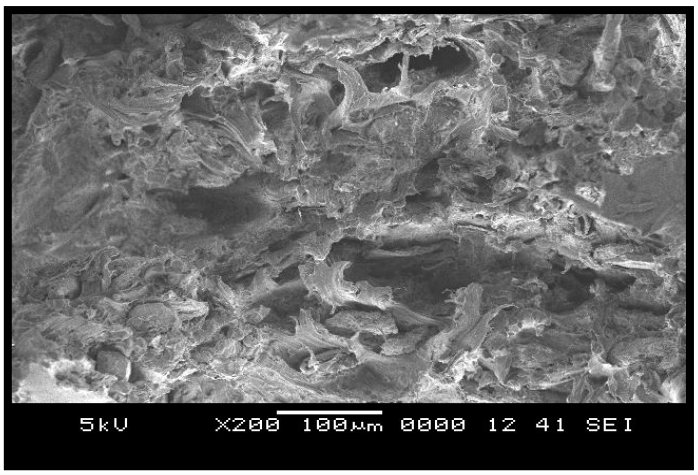

Figure 4. SEM micrograph of tensile fracture surface of uncompatibilized LDPE/CS biocomposites with MAPE (20php) at magnification 200X.

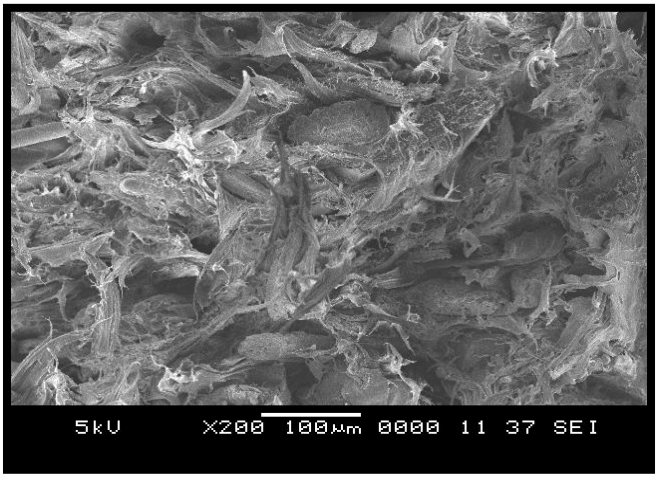

Figure 5. SEM micrograph of tensile fracture surface of uncompatibilized LDPE/CS biocomposites with MAPE (40php) at magnification 200X.

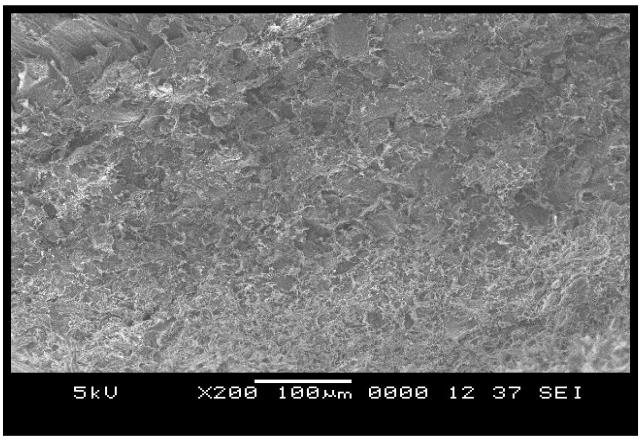

Figure 6. SEM micrograph of tensile fracture surface of compatibilized LDPE/CS biocomposites with MAPE (20php) at magnification 200X.

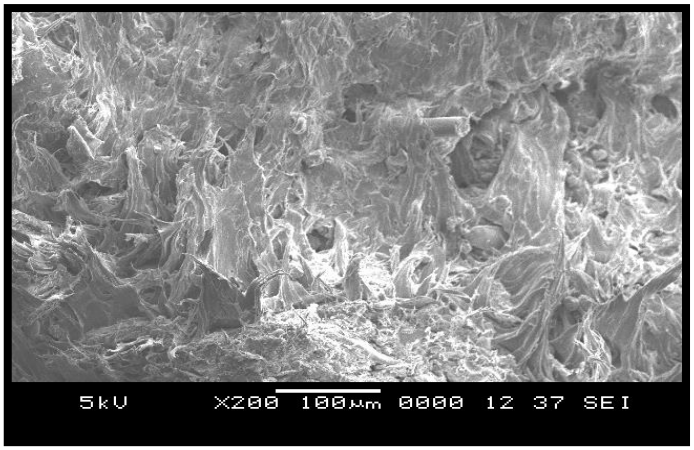

Figure 7. SEM micrograph of tensile fracture surface of compatibilized LDPE/CS biocomposites with MAPE (40php) at magnification 200X.

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. Compatibilized LDPE/CS with MAPE yield the high tensile properties. SEM studies indicate that the interfacial adhesion between CS and LDPE matrix improved with presence of MAPE. This proof better wettability between filler and matrix. The results supported with the higher tensile properties of compatibilized biocomposites with MAPE as discussed in section 3.

REFERENCES

Cao, Y., Shibata, S., Fukumoto, I. Mechanical properties of biodegradable composites reinforced with bagasse fibre before and after alkali treatment. Composites: Part A, 37, 423-429 (2006).

Alemdar, A., & Sain, M. Biocomposites from wheat straw nanofibers: Morphology, thermal and mechanical properties. Composites Sciences and Technology, 68, 557-565(2008).

Yang et al, Effect of different compatibilizing agents on the mechanical properties of lignocellulosic material filled polyethylene bio-composites. Composites Structure, 79, 369-375 (2007).

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

Bledzki, A. K., & Gassan, J. Composites reinforced with cellulose based fibres. Prog. Polym. Sci., 24, 221–274 (1999).

Prachayawakaron, J., Sangnitidej, P., Boonpasith, P. Properties of thermoplastic rice starch composites reinforced byb cotton fiber or low-density polyethylene, Carbohydrate Polymers, 81, 425-433 (2010).

Salmah, H., & Azieyanti, A.N. Properties of recycled polyethylene/chitosan composites: The effect of Polyethylene Graft Maleic Anhydride, Journal of Reinforced Plastics and Composites 30, 195-202 (2011).

Lei, et al. Preparation and properties of recycled HDPE/Natural Fiber Composites: Part A, 38, 1664-1674(2007).