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Performance of Corn Husk Fiber Reinforced Thermoplastic Biocomposites

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Abstract

This paper presented corn husk fiber (CHF) reinforced High Density Polyethylene / Polyolefin Elastomer (HDPE / POE) biocomposites. The biocomposites were prepared by melt blending using Brabender Plasti-Corder Lab-Station internal mixer. The effects of filler content and composition of matrix HDPE/POE on properties of CHF reinforced thermoplastic biocomposites were investigated by measuring mechanical properties and morphology. The mechanical properties such as tensile strength, elongation at break and tensile modulus were measured with the filler content 10%, 20%, 30% and 40% CHF at matrix composition of HDPE/POE 60:40 and 40:60 ratios. The tensile strength of biocomposites at 60:40 ratios was decreased with the increasing of filler content. While the biocomposites at 40:60 ratios showed the lowest tensile strength at 30% filler content. However, the elongation at break was decreased with increasing of filler content and tensile modulus was increased with the increasing of filler content for both HDPE/POE matrices ratio. The study reveal that the addition of CHF increased the stiffness of HDPE/POE matrix wherein lowering the flexibility of the composites. Field emission scanning electron microscopy (FESEM) micrograph was used to observe the fibre dispersion, matrix wetting as well as physical interaction between the fiber and the matrix. The results showed that the effects of filler content on mechanical properties and morphology were influenced by CHF.

Keyword: Biocomposites, mechanical properties, natural fiber

INTRODUCTION

The increasing of natural fibres usage such as corn husk is prominent in the industry. Most natural fibers from plant are lignocellulose fibers that they actually comprise of both lignin and cellulose [1]. Lignocellulose fibers can be considered as self-reinforcing as the lignin is a natural resin and cellulose the reinforcing fiber. Industry emphasize to choose lignocellulose fibres as composite because it is abundant, cheap and strong [1].

HDPE has higher tensile strength compared to other forms of polyethylene. It also a low-cost polymer with good processibility. HDPE are an excellence resistance of solvent and alkali.

POE are widely exploited for automotive applications, offering additional sustainability and innovativeness. A further way of developing a product with tailored properties and suitable for high demanding applications is blending two polymers.

In previous finding, there are research on the effect of adding CHF on acoustical and non-acoustics properties of polyester composites. In addition, the effects of fiber content on the tensile properties and microstructures via SEM have been analyzed. The results of this study could contribute to engineering applications, especially as sound absorber [8]. These finding used polyester resin and corn husk fiber.

METHODOLOGY

In this study, HDPE and POE were used as the polymer matrices. HDPE with a density of 0.95 g/cm^3, melt flow rate (MFR) of 1.1 g/10 min, and Tm at 135 °C was supplied by Polyethylene Malaysia Sdn Bhd (Malaysia). Meanwhile, POE was obtained from Sabic Innovative Plastics Sdn. Bhd. The corn husks were gained from corn harvested in Marang, Terengganu. While the corn husk fiber was prepared in the laboratory of Universiti Selangor.

Fiber and Biocomposites Preparation

The sieved corn husk fibers were soaked and stirred with distilled water for 24 h. Next, the fibers were stirred for 30 min with 4% NaOH solutions. After that, the fiber was rinsed with distilled water until the pH was neutral. Then, the fibers were dried at room temperature for 3 days, and oven-dried at 80 °C for 24 h to remove moisture by using Universal Oven [7].

The biocomposites were prepared by melt blending using Brabender Plasti-Corder Lab-Station internal mixer. The processing temperature was set at 160 °C, while the rotation speed was fixed at 50 rpm for 15 min. Prior to blending, the fiber was oven-dried for 1 h at 105 °C to eliminate moisture in the vacuum oven [7]. During the process of biocomposites blending, CHF were added for 3 min. Next, POE were added and followed by HDPE and MAPE after 5 min. The fibers and polymer were blended together for 15 min. The samples were compressed for 20 min at 145 °C under 8 GPa pressure using a hot press to produce 1mm thick sheets for tensile testing.

RESULTS AND DISCUSSION

Mechanical Properties and Morphology of Biocomposites at Matrix Composition HDPE/POE 60:40 Ratio

Tensile Strength

Figure 1 (a) shows the tensile strength. Result showed that the tensile strength was decreased as the filler contents were increased from 10% to 40%. This was attributed to lack of facial interaction between matrix and the filler. Therefore, the tensile strength of matrix tends to represent more on the properties. The graph showed tensile strength at 40% of CHF was the lowest because excessiveness incorporation of filler may lead to the filler agglomeration in the polymer matrix. Besides, agglomeration led to difficulties in achieving homogenous dispersion of CHF. Based on previous study [1], agglomeration will weaken the tensile strength. Agglomeration caused a weak bonding between fiber and thermoplastic matrix. As natural fiber has poor compatibility with thermoplastic matrices, agglomeration can easily occur in biocomposites.

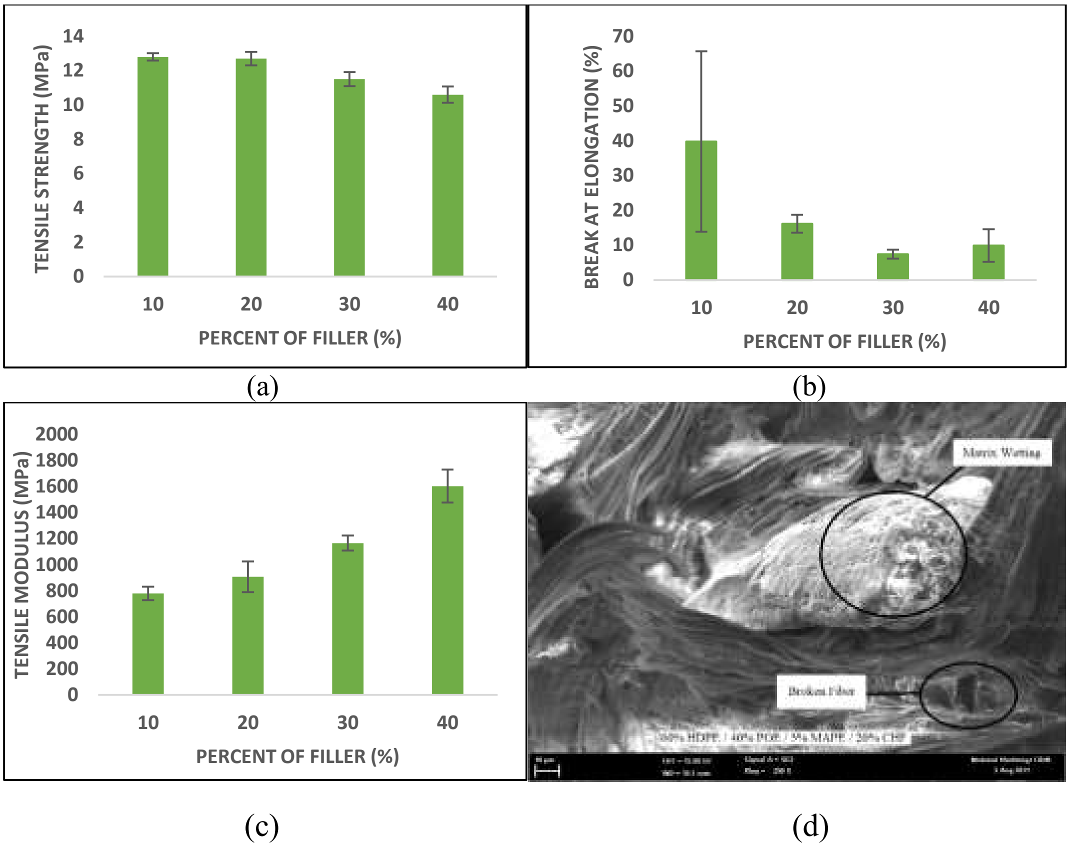


Figure 1 Mechanical Properties of HDPE/POE 60:40 (a) Tensile strength (b) Elongation at break (c) Tensile modulus Figure (d) FESEM of HDPE/POE 60:40 at 20% CHF

Elongation at Break
Figure 1 (b) shows elongation at break was decreased in as the percentage of fillers were increased. The addition of rigid CHF particles restricted the polymer chains mobility, which increased brittleness of biocomposites. Therefore, this result in decreased of elongation at break. This is a common trend found by other researchers [2]. Filler incorporation into a polymer matrix increased the stiffness and hardness resulted in decrease of ductility of the biocomposites [1]. Hence, as the CHF increases, the ductility decreases.

Tensile Modulus
The influence of filler content on tensile modulus CHF reinforced HDPE/POE biocomposites is shown in Figure 1 (c). The result indicated that the increase of filler content has increased the tensile modulus of biocomposites. Tensile modulus of biocomposites at 40% filler content was the highest among the others filler content biocomposites. It was due to the fact of the friction at interface region between CHF particles and HDPE/POE matrix which led to a rigid interface that restricted the polymer chain mobility. As reported by [2], this led to increase the rigidity and stiffness of composites.

Morphology
Figure 1 (d) shows the micrograph FESEM of 20% CHF filler content. The micrograph showed there were matrix wetting on the surfaced of biocomposites. This indicates there were interaction between fiber and matrix. The strong interaction contributes to the increment of tensile strength.

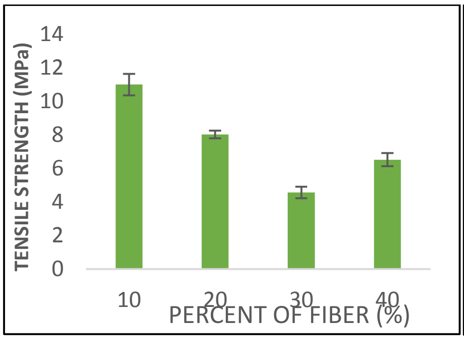
Mechanical Properties and Morphology of Biocomposites at Matrix Composition HDPE/POE 40:60 Ratio

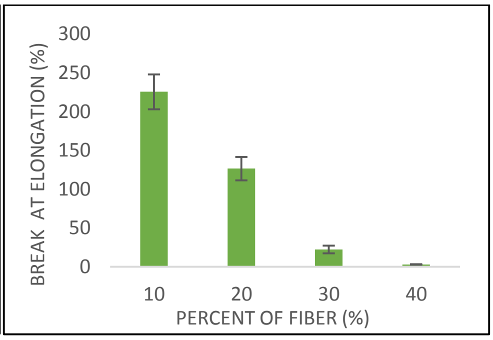
Tensile Strength

The incorporation of CHF filler decreased the tensile strength of biocomposites. As shown in Figure 2 (a), the decreased of tensile strength from 10% to 30% filler content. Agglomeration of filler had declined the tensile properties with the addition of filler in the biocomposites. Agglomeration were generated flaws and were created voids between filler-filler and filler-matrix, thus diminishing its tensile strength [5]. The decrease of tensile strength showed by the fillers could be due to high CHF agglomeration resulting in difficult stress transmission from matrix to fiber and the disturbance of the continuity of the matrix phase [8].

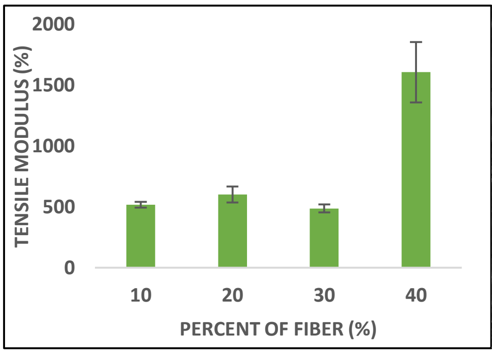
Elongation at Break

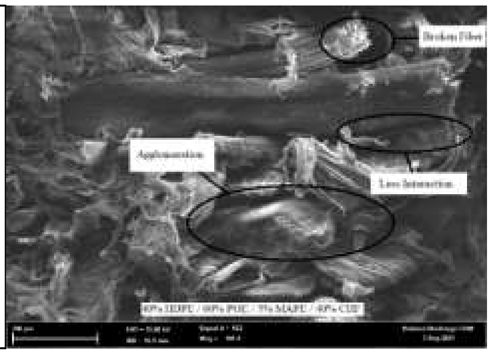
The elongation at break of the biocomposites was shown in Figure 2 (b), gradually decreased at higher filler content. The CHF is rigid particulate filler and the addition of CHF were reduced the ductility of HDPE/POE matrix. The presence of filler agglomeration especially at higher percent of filler might act as stress concentrator and it were contributed to failure of composites at lower elongation. Thus, filler agglomeration also attributed to decrease the flexibility of HDPE/POE matrix [4]. This indicated the result of the lowest elongation at break at 40% filler content.





(a) (b)





(c) (d)

Figure 2 Mechanical Properties of HDPE/POE 40:60 (a) Tensile strength (b) Elongation at break (c)Tensile modulus (d) FESEM of HDPE/POE 40:60 at 40% CHF

Tensile Modulus

Figure 2 (c) shows a biocomposites at 40% filler had the highest tensile modulus from other filler loads. The increased in tensile modulus corresponded to the increasing of more fillers, where its intrinsic properties as a rigid agent were exhibited high stiffness. Nevertheless, based on [3] stated that the use of high POE content allows obtaining high impact properties but results in a substantial loss in elastic modulus. Since the dominant of the load contained 40:60 HDPE/POE, the load will have decreased in tensile modulus. However, fiber had help to sustain the stiffness of the biocomposites.

Morphology
Figure 2 (d) shows micrograph FESEM at 40% CHF filler content. The micrograph showed agglomeration occurred. At 40% filler content, the agglomeration was occurred because of excessive incorporation of filler in the matrix. Agglomeration creates a weak point in the matrix which lead to reduction in tensile strength. There was also matrix wetting spotted in the micrograph.

CONCLUSION

Based on the results of this study, the tensile strength and the elongation at break was decreased while tensile modulus was increased with the increasing of CHF fillers for both biocomposites composition HDPE/POE 60:40 and 40:60. Morphology examination showed the matrix wetting on CHF as well as least physical interaction between the fiber and the matrix.

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