Exploitation of Mineralized Fillers for Increasing Mechanical Properties of Polymer Biocomposites by

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INTRODUCTION

Talc is a hydrous magnesium silicate with the chemical formula of Mg3Si4O10(OH)2 which is one of the hydrophobic minerals (Yekeler et al. 2004). The hydrophobic nature of the basal surfaces is due to the atoms exposed on the surface are linked together by siloxane (Si-O-Si) bonds, thus they could not form strong hydrogen bonding with water (Şener and Özyılmaz 2010). Calcium carbonate with the chemical formula of CaCO3 is a hydrophilic mineral (Wang et al. 2010), low-cost and non-toxic substance that has been widely used as functional filler in polymer composites for improving their physicochemical properties. The effects of talc and calcium carbonate minerals on the stiffness and toughness properties of the LDPE/KCF biocomposites were studied.

MATERIALS AND METHOD

LDPE (coating grade) was purchased from the Lotte Chemical Titan (M) Sdn. Bhd., Malaysia. KCF (420 μm) was attained from the National Kenaf and Tobacco Board, Malaysia. Talc (10 μm) was procured from the Sigma-Aldrich (M) Sdn. Bhd., Malaysia. Calcium carbonate (10 μm) was acquired from Merck (M) Sdn. Bhd., Malaysia. All materials were used as received without further modification. Brabender internal mixer machine was used to prepare the biocomposites. The mixing was done at a temperature of 150°C, and the rotor speed was fixed at 60 rpm. First of all, 24g of LDPE was inserted into the mixing chamber, and allowed to melt for 3 minutes. After that, 16g of KCF was added into the chamber, and permitted to mix for 6 minutes. Finally, talc or calcium carbonate was incorporated into the composite, and allowed to blend for 6 minutes. The contents of the talc and calcium carbonate were varied as 0, 3, 9 and 15 wt.%.

RESULTS AND DISCUSSION

Figure 1 demonstrated the tensile strength results of the LDPE/KCF biocomposites with different loadings of talc and calcium carbonate, respectively. From the graph in Figure 1, it showed that with the incorporation of talc from 3 to 15 wt.%, the tensile strength of the biocomposites has increased. Nonetheless, the tensile strength of the biocomposite without talc is lower than the biocomposites containing talc. This implied that the LDPE/KCF biocomposites with the incorporation of talc have high stiffness feature where they can withstand high loads before failure.

A different phenomenon occurred to the LDPE/KCF biocomposites containing calcium carbonate. It is clearly seen that the tensile strength of the biocomposite without calcium carbonate is higher than the biocomposites containing calcium carbonate. The incorporation of calcium carbonate to the biocomposites system has not offered improvement in their tensile strength. Thus, the results evidenced that the LDPE/KCF biocomposites with the incorporation of calcium carbonate are less stiff compared to the biocomposites containing talc and without calcium carbonate.

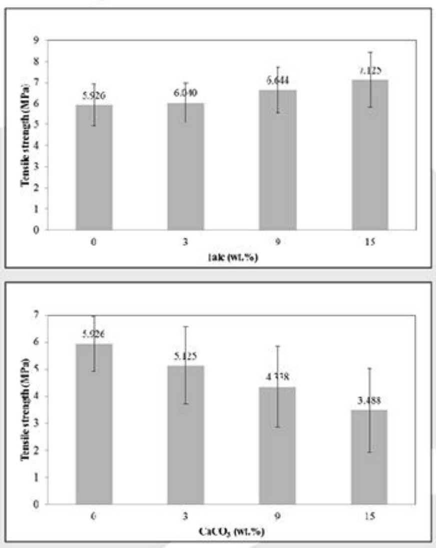

Figure 1. Tensile strength of the LDPE/KCF biocomposites with different loadings of talc (above) and calcium carbonate (below)

Figure 2 exhibited the results of the impact strength of the LDPE/KCF biocomposites with different percentages of talc and calcium carbonate. From these data, it is clearly perceived that the impact strength results are inversely proportional to the tensile strength results. It also noticed that the decreasing trend of the impact strength was obtained as the talc loading increased from 3 to 15 wt.%. Hence, this evidenced that with the incorporation of talc to the LDPE/KCF biocomposites, it does not improve the toughness of the biocomposites, but it does enhance the brittleness of the biocomposites.

On the other hand, the different observation has been acquired when the biocomposites were incorporated with calcium carbonate. From Figure 2, it is obviously seen that the impact strengths for the biocomposites with the incorporation of calcium carbonate are greater than the biocomposite without calcium carbonate. The impact strengths have also increased as the calcium carbonate loading increased from 3 to 15 wt.%. Therefore, this proved that with the incorporation of calcium carbonate to the LDPE/KCF biocomposites, it provided more toughness and less brittleness to the biocomposites.

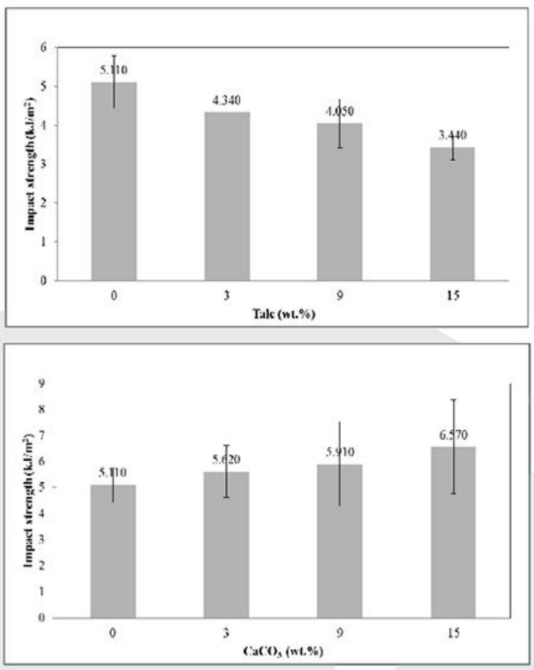

Figure 2. Impact strength of the LDPE/KCF biocomposites with different percentages of talc (above) and calcium carbonate (below)

CONCLUSION

From the attained results, it showed that the stiffness of the biocomposites can be improved with the incorporation of hydrophobic mineral such as talc as secondary filler. Instead, calcium carbonate can be considered as the good hydrophilic mineral filler for improving the toughness of the LDPE/KCF biocomposites compared to talc. The improvement in the stiffness and toughness are probably due to the ability of the minerals to withstand and absorb exerted load and energy, respectively.

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