Mechanical Properties of Kenaf Reinforced Polypropylene Composites Added with Oil Palm Shell Powder and Its Activated Carbon

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ABSTRACT – The application of natural fibers in composite is very encouraging because of its many benefits such as more environmental friendly and cost reduction. The mechanical properties of kenaf fiber reinforced polypropylene composite added with two different types of bio-based fillers, namely oil palm shell powder (OPSP) and activated carbon of oil palm shell powder (ACOPSP) are studied. The composites were prepared by melt mixing of the materials using internal mixer, followed by extrusion and compression molding processes. The samples were prepared at 4 different weight percentage of filler content, i.e., 0, 5, 10 and 15 phc.

1. INTRODUCTION

Natural fiber reinforced composites including kenaf fiber reinforced polypropylene composite have become a potential structural material with many attractive properties such as low density, cost effective, higher deformability and less abrasive. In recent times, kenaf has been used as an alternative to replace wood in pulp and paper industries [1].

Oil palm shell is an industrial waste produced by palm oil industry, which is one of the main sources in Malaysia's economy. Besides producing crude palm oil as the main product, it also produces a million of tonnes of oil palm waste in various forms such as fronds, trunk, empty fruit bunch and shell [2]. Oil palm shell is the shell fractions left after the nut has been removed after crushing in the palm oil mill.

Activated carbon is carbonaceous in nature and exhibit high content of organic substance and in particulate form. It can be produced from biomass and has the potential as alternative sources of fillers. Oil palm shell contains high lignocellulosic fibers and can be used to produce biocarbon (activated carbon) after undergo pyrolysis and carbonization process [3].

2. EXPERIMENTAL

2.1 Materials

Kenaf fibers were in non-woven sheets and supplied by Kenaf Natural Fiber Industries Sdn. Bhd. The oil palm shells were obtained from Jugra Oil Palm Sdn. Bhd. The activated carbon of oil palm shell came in granular form and produced by Standards and Industrial Research Institute of Malaysia (SIRIM). The polypropylene (PP) was purchased from Polypropylene Malaysia Sdn. Bhd. The coupling agent used in this experiment was maleic anhydride grafted polypropylene (MAgPP) and produced by Sigma Aldrich.

2.2 Sample Preparation and Testing

Initially, oil palm shells were cleaned with water and dried under sunlight for 10 hours. To produce the powder of oil palm shell (OPSP) and activated carbon of oil palm shell (ACOPSP), the oil palm shell and its activated carbon aggregates were crushed using crusher and subsequently pulverized by using a variable speed rotor mill (Pulverisette, FRITSCH). The OPSP and ACOPSP particles were then sieved using a vibratory sieve shaker (Analysette, FRITSCH) to obtain particle size of approximately 45 µm. The amounts of OPSP and ACOPSP were varied at 0, 5, 10, 15 per hundred compounds (phc), while the composition of kenaf/PP was fixed at 30/70 wt%. The formulations for the composites are shown in Table 1.

Table 1 Formulations of the OPSP/kenaf/PP and ACOPSP/kenaf/PP composites.

Kenaf (wt%)	PP (wt%)	OPSP or ACOPSP (phc)	MAgPP (phc)
30	70	0	3
		5	
		10	
		15	

Fabrication of composite samples was carried out by sandwiching a non-woven kenaf with OPSP/PP or ACOPSP/PP sheets. The sheets were prepared by melt mixing PP and the biomass-derived filler using internal mixer at 180 °C for 10 min, followed by extrusion and lastly, compression moulding for 10 min at 180 °C and 10 MPa. Finally, it was cooled at room temperatures for 10 minutes, before being cut into standard samples.

Tensile and flexural tests were performed using Universal Testing Machine according to ASTM D638 and ASTM D790, respectively. For each composition, the average value for five measurements was taken as the result.

3. RESULTS AND DISCUSSION

The results obtained from the tensile and flexural tests of the composites are shown in Figures 1 – 4. The tensile strength for OPSP composite increased as the filler content added from 0 to 15phc. For the ACOPSP composite, the tensile strength increased at 5phc, but decreased when the filler content was further increased to 10 and 15 phc.

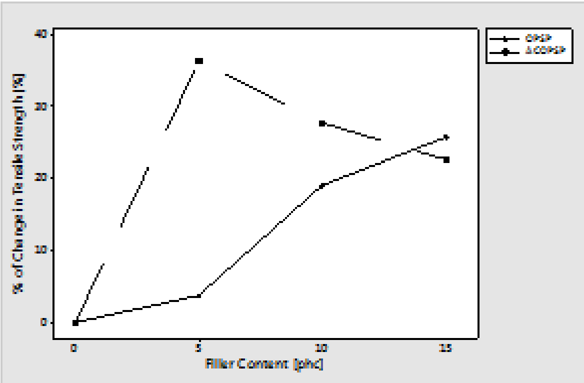

Figure 1 Percentage of change in tensile strength of the OPSP and ACOPSP composites

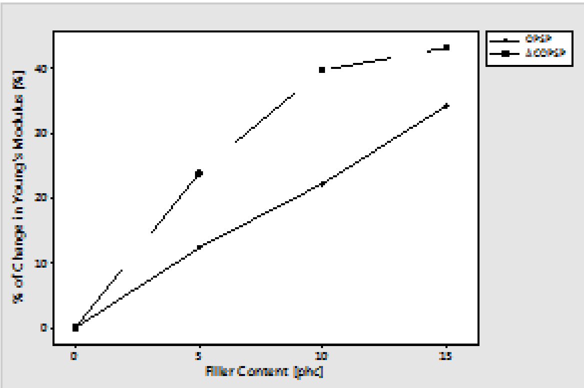

Figure 2 Percentage of change in tensile modulus of the OPSP and ACOPSP composites

The flexural strength shows a similar result to that of tensile strength in which the OPSP composite show a consistent increase in flexural strength with the addition of OPSP filler up to 15 phc, while the ACOPSP composite show a decrease as the filler content is increased above 5 phc. It is suggested that the decrease observed in the composite added with higher content of ACOPSP is possibly due the agglomeration of the ACOPSP filler, which is associated with its higher specific surface area as observed by the SEM analysis.

The Young's and flexural moduli for both composites show a similar trend. There is an improvement of the modulus properties when the composites were added with the biomass fillers from 0 to 15 phc, however the increase is more significant in flexural modulus than tensile modulus.

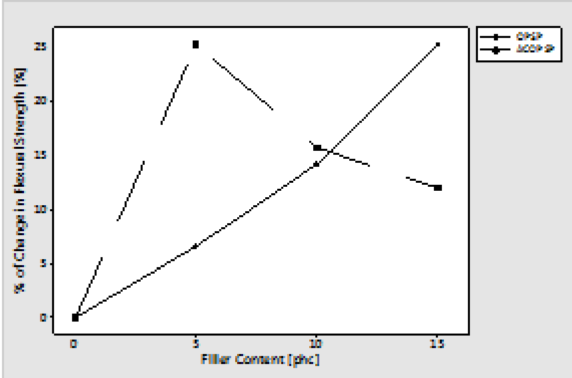

Figure 3 Percentage of change in flexural strength of the OPSP and ACOPSP composites

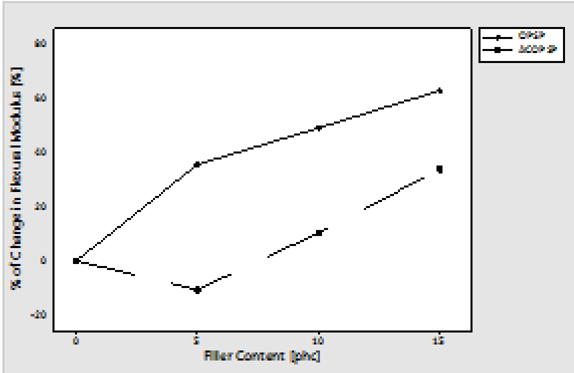

Figure 4 percentage of change in flexural modulus of the OPSP and ACOPSP composites

4. CONCLUSIONS

It can be concluded that the addition of OPSP and ACOPSP fillers to the kenaf/polypropylene composite is effective to improve the mechanical properties of the composite. Both types of composites show a consistent increase in tensile and flexural moduli with the increase of filler content. Meanwhile, only OPSP composite shows a consistent increase in tensile and flexural strength with the increase of OPSP content, but ACOPSP composite started to decrease in those values when then amount of ACOPSP is more than 5 phc.

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