MECHANICAL PROPERTIES OF COIR FIBER REINFORCED POLYPROPYLENE COMPOSITES

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Introduction

The potential and advantages of natural fibers as reinforcement material have been given significant attention for the past few decades [1]. This is due to the fact that natural fibers are lightweight, low in cost and environmental friendly. Natural fiber composites with thermoplastic and thermoset matrices are now utilized for door panels, seat backs, headliners, dashboards and other interior parts by European car manufacturers [2].

In this research, investigations are done on the mechanical properties of untreated and chemical treated coir fibers. Coir fibers are easily obtained in Sarawak and are a major concern to be recycled as reinforcement material to substitute synthetic fibers. Static tensile test, flexural test and water absorption test are done and comparison are made between the raw coir fiber (untreated) and treated coir fiber reinforced with polypropylene (PP) matrix. The results may be used to further investigate the relevant chemical treatment or manufacturing processes to optimize the mechanical properties of coir fiber as a replacement material for synthetic fiber.

Experimental

Materials

The major materials in this research are coir fiber and polypropylene resin. The coir fibers are obtained from local sources. The raw coir fibers are cut into lengths of 20-30mm before chemical treatment. Chemical solution for fiber treatment are sodium hydroxide (NaOH), sodium nitrate ($NaNO_3$) and aniline (C_6H_7N) [3].

Composite fabrication

Raw (untreated) coir fiber and chemical treated coir fiber are mixed with polypropylene resin and both types of composite are tested in this research. The weight ratio of the fiber and matrix are calculated by using the weight percentage (10%, 15%, 20%, 25% and 30%).

For treated coir fiber, they are first left to dry naturally. Then, they are treated with the mixture of the three chemical solutions, and then thoroughly washed with distilled water for 1 hour. The fibers are then oven dried to remove moisture content. Next, they are cut to approximately 3mm in length. Finally, they are mixed with polypropylene matrix at different weight fractions.

Coir fiber reinforced polypropylene composites are fabricated using the hot press molding machine. The mixture of coir fiber and polypropylene are poured into the mould and are compressed for 1 hour with a pressure of 500Pa at 170°C. The composite are then cut into specified shape according to ASTM standard for each different test.

Experimental and apparatus

In this research, three types of testing which are static tensile test, three point bending and water absorption tests are conducted to both untreated and treated specimen and the results are compared. The entire tests are conducted according to American Standard Testing Material (ASTM). The tensile test are conducted using Shimadzu AG-ISMS test machine at a cross head of 2mm/min. The specimens are dog-bone shape specimens which are 148mm in length, 10mm width and 4mm in thickness.

The flexural tests are conducted using the same test machine with tensile test. The specimen dimensions are 79mm in length, 10mm in width and 4.1mm in thickness.

For the water absorption test, the specimens are cut in to rectangular shape with dimension of 39mm×10mm with the thickness of 4.1mm. The specimens are dried in the oven at 105°C for 2 hours and the weights are taken. The dried and weighted specimens are soaked in distilled water for 24 hours. The weight of the specimens is then taken after excess water is removed gently using dry cloth. The percentage increase in weight after immersion is calculated based on equation below:

$$\text{Increase in weight}(\%) = \frac{\text{wet wt} - \text{conditioned wt}}{\text{conditioned wt}} \times 100$$

The microstructures of untreated and treated coir fiber composite are observed under Scanning Electron Microscope (SEM) and both are compared.

Results and discussion

The summarized results for tensile test are shown in figure 1. It shows a significant increase of tensile strength for both untreated and treated fiber composites. However, after 20% fiber load, the tensile strength decreases. Both composites have a highest tensile strength at 20% fiber loading. The treated fiber composite exhibits higher tensile strength value compared to untreated fiber composite for all fiber loading ratio.

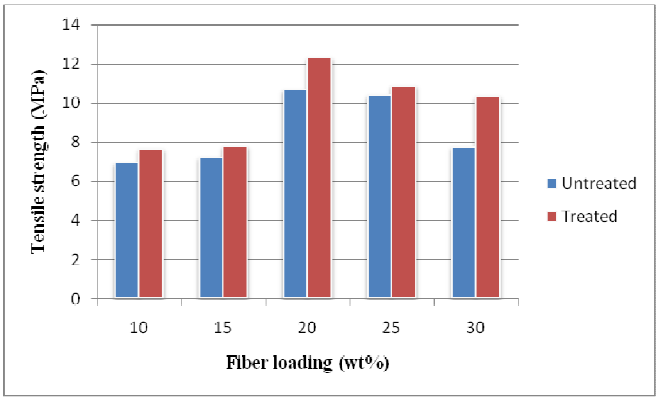

Figure 1: Tensile strength test result

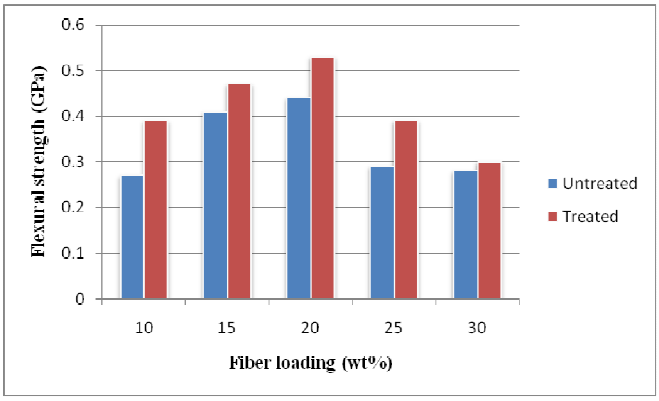

Figure 2: Flexural strength test result

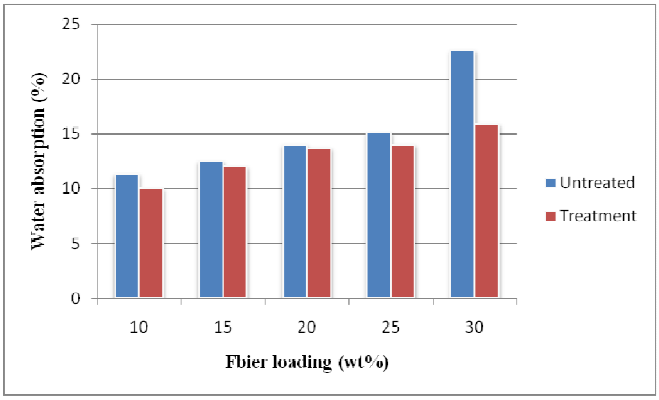

Figure 3: Water absorption test result

The flexural test results for untreated and treated coir fiber composite are shown in figure 2. It is observed that the flexural strength decreases after 20% fiber load for both composites. Treated coir fiber composites yielded higher flexural strength compared to untreated coir fiber composite. The mixture of 20% fiber loading exhibits the highest value of tensile strength for both composites.

The results for water absorption test are shown in figure 3. The water absorption shows a significant increase as the fiber loading increases for both composites. The water absorption for treated coir fiber composites are less than untreated coir fiber composite.

SEM micrographs of 20% and 30% untreated and treated coir fiber composites are shown in figure 4. The images of untreated coir fiber show that the fibers are weakly dispersed in the composite. However, images of treated coir fiber composite show a better dispersion of the fiber into the polypropylene matrix.

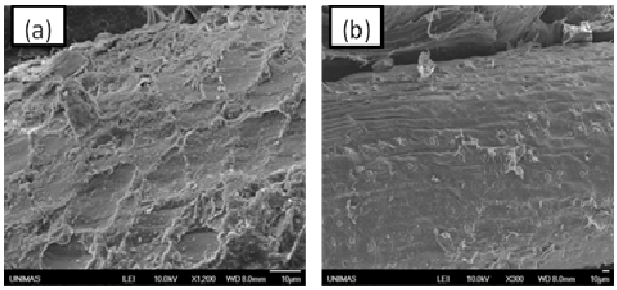

Figure 4: Representative SEM micrograph

Conclusion

The mechanical properties of treated and untreated coir fiber reinforced composite are investigated in terms of tensile strengths, flexural strengths and water absorption percentage. Treated coir fiber exhibits slightly higher tensile and flexural strength compared to untreated coir fiber composite. Both tensile and flexural strength are at the highest value when the fiber loading is 20%. The water absorption percentage for treated coir fiber composites are less than untreated coir fiber composites.

It can be concluded that the chemical treatment conducted to the coir fiber has improved the mechanical properties of the fiber by modifying the surface of the coir fiber and make it more compatible with polypropylenes matrix. Thus, the interfacial bonding between fiber and matrix are also increased.

References

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[3] Mani P., Satyanarayanan K. G. (2000), "Effects of the surface treatments of lignocellulosic fibres on their debonding stress", *Journal of Adhesion Science and Technology*, 4; 17-24.