TENSILE BEHAVIOR OF HYBRID NATURAL/GLASS FIBERS REINFORCED COMPOSITES AT DIFFERENT TEMPERATURES

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Tensile Behavior of Hybrid Natural/Glass Fibers Reinforced Composites at Different Temperatures

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Abstract—**Nowadays, natural fiber reinforced composites are given bright opportunities to replace synthetic fiber reinforced composites especially in automotive sectors. Natural fibers offer considerable high strength, low weight and less abrasive effect. But this fiber is incompatible to polymeric material which leads to interfacial bonding problems. To encounter this problem, hybridization between natural and synthetic fibers are formulated and tested. In this work, coir and glass fibers are blended mechanically with polypropylene granular to homogenize the composite mixture. Both fibers are chemically treated to enhance the bonding with matrix material. It is then extruded into identical dimensions and shape (dog-bone tensile specimen). Several different temperatures are selected ranging from room temperature to 100^{0}C and the specimens are quasi-statically stressed at constant cross-head displacement 1.5mm/min. It is found that the interaction between fiber hybridizations and temperatures played an important role in determining the tensile behavior of this composite. Scanning electron microscope (SEM) is used to observe the fracture surfaces of these samples after tensile tests. Different toughening mechanisms are observed such as fiber pull-out and interfacial detachments which are depend on the temperature and fiber volume fraction.**

Keywords: natural reinforced composites, fiber hybridizations, tensile behavior, high temperatures, interfacial debonding

I. INTRODUCTION

The utilization of the natural fiber reinforced composites in the automotive and furniture sectors are not new and this composite is increasingly used from time to time. Most of these composites are used as load bearing application parts. This is because the composites have considerable low strength of mechanical strength. The low strength is due to the lack of interfacial bonding between cellulosic fiber and polymeric matrix material [1]–[3]. Generally to enhance the interface bonding between fibers and matrix, coupling agent is used. The natural fibers are treated with the chemical solution in order to create a layer of silane on the fibers surface.

Therefore it will increase the wetability behavior of the matrix resin with the fibers. On the other hand, hybridization of the both natural and glass fibers is introduced to overcome the low composite strength if the composite is reinforced with natural fiber alone. This process is hoped to increase the composites sustainability under any loading condition. This present work explores the effect of hybridization of both natural and glass fibers at considerable high temperatures. Different temperature ranges are selected in order to study the tensile response of the hybrid composites. Fracture surface of the samples are also investigated to study the toughening mechanisms of the fibers for all temperatures and fiber hybridization differences.

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II. MATERIAL AND METHODS

Coir fibers are obtained locally in Batu Pahat, Johor, Malaysia. These fibers experienced a purification process where the fibers were soaked in 5% sodium solution and mechanically stirred for 1 hour. This process was conducted in order to remove the unwanted layers on the fiber surfaces. Then, treated fibers were dried in furnace environment at constant temperature 80^{0}C for 24 hour to make sure the cellulosic fibers were completely dried. The removal of unwanted fiber layers is to improve the stress transfer from the matrix to the fibers. In order to enhance the wetability behavior upon the fibers, fibers were treated again with silane coupling agent. 10% silane solution was prepared with methanol in weight. Coupling agent is normally used to enhance the compatibility between the fibers and matrix. Sodium treated fibers were immersed into silane solution for 30 minutes at room temperature and it was mechanically stirred at constant speed. Stirring process was carried out to homogenize the distribution of the silane onto the fiber surfaces. Then, they were dried in furnace at temperature 50^{0}C for 12 hours. The as-received glass fibers do not experienced any chemical treatment and it was assumed that the fiber surfaces were free from grease or oil. Both fibers (natural and glass fibers) were cut into specific length of about 10 mm. Fibers and polypropylene granular were mixed together using ball milling for 3 hours to get homogenized composite mixture and melted before they were feed into extrusion machine. In this work, extrusion parameters were kept constant throughout the process such feeding and extrusion rate and temperature. Then, it was extruded into identical standard samples shape and dimension. After 24 hours, the samples were removed from the mould and they were cured in an atmospheric environment and under controlled relative humidity about 55% for another 24 hours in order to have better composite hardness and shrinkage. Different fiber volume fractions are selected such as 5, 10, 15 and 20%. Hybridization of the fibers is conducted by using half of natural fibers and other half for glass fibers. Tensile test was conducted using universal testing machine using constant cross-head displacement 1.5mm/min. Four heating temperatures were selected including room temperature, 50, 75 and 100^{0}C. Before any tensile test, the samples were heated for 1 hour. The samples were stressed until the fracture to occur and stress-strain curves were extracted from these tests. The results obtained from the tests were related to temperatures, fiber volume fractions and fracture mechanisms. Scanning electron microscope (SEM) was used to observe the fracture surfaces of the samples under quasi-static loading.

III. Results and Discussion

A. The Effect of Temperature on the Elastic Modulus

'Figure 1.0' shows the influence of temperature on the elastic modulus. At room temperature (25^{0}C), the effect of fiber volume fractions are not very significant. Increasing the fiber fractions reduce the elastic modulus, this finding is well agreed with previous research works [1]-[3]. When the heating temperature increases up to 50^{0}C, large elastic modulus reduction is detected. The behavior may be due to breaking of the Si-O-Si bond on the fibers to the matrix as reported by M.M Thwe and Kin L. (2003). When the interfacial bonding was break, the efficiency of the stress transfer is lowered and therefore reducing the composite strength. 'Figure 2.0' reveals the fracture surface of the composite heated at 50^{0}C under tensile loading. At low magnification, longer pull-out fibers are observed and indicated the ineffectiveness of the stress transfer between matrix to the fibers.

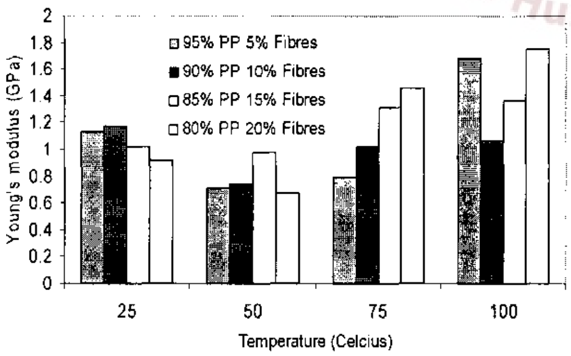

Figure 1. The effect of temperature on the modulus of elasticity at different fiber volume fractions

Figure 2. Fracture surface of 2.5 % fiber volume fraction at 50^{0}C fiber

B. The Effect of Temperature on the Maximum Load

'Figure 3.0' shows the effect of temperatures on the maximum load for different fiber volume fractions. It can be seen here that, the temperatures have played an important role in increasing the mechanical strength. But at higher temperature (100^{0}C), significant composite strength reduction occurred especially for high content of fiber fractions. When the fibers are exposed to the high temperature, they tend to shrink themselves and this will leave some spaces between matrix and fibers interfaces. Stress would concentrate at these sites and degrade the composite integrity. 'Figure 3.0' also indicates that when the 10% fiber volume fraction composites are stressed at temperature 75^{0}C, the composite strength suddenly increased. The increment can be related to the toughening mechanism that is observed in 'figure 4.0'. From this figure obviously show that shorter pull out fibers are observed indicating the significance of stress transfer from the matrix to the fibers.

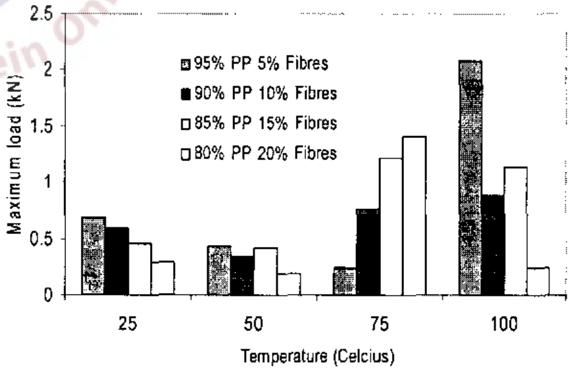

Figure 3. The effect of temperature on the maximum load for different fiber volume fractions

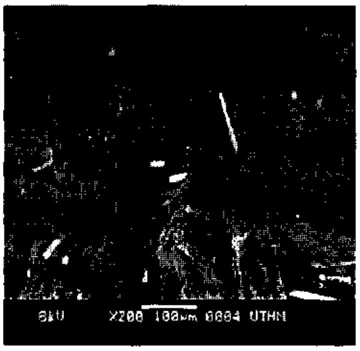

Figure 4. The fracture surface of the 10% fiber volume fraction reinforced composites at 75^{0}C

C. The Effect of Fiber Volume Fraction on the Ultimate Tensile Strength.

'Figure 5.0' shows that the significant role of fiber volume fractions on the ultimate tensile strength. It can be seen here that at lower temperatures (less than 50^{0}C), heating temperatures not played to modify the tensile strength of the composites. While when the composites are exposed to the higher temperatures large tensile strength reduction occurred when the fiber volume fractions increased. High temperature responsible to reduce the moisture content of the fibers and therefore reducing the bonding at the interfacial boundary between the matrix and the fibers. 'Figure 6.0' reveals the fracture surface of the 20% fiber volume fraction reinforced composites. From this micrograph, glass fibers are well embedded in the matrix while for the natural fiber (bigger in size), the bonding incompatibility between fibers and matrix is not strong enough to support shear force from the matrix to the fibers.

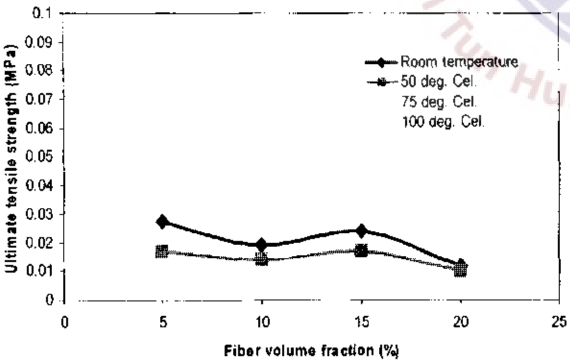

Figure 5. The effect of fiber volume fraction on the ultimate tensile strength for different heating temperatures

Figure 6. The fracture surface of the 20% fiber volume fraction reinforced composites at 100^{0}C

IV. CONCLUSION

The main objective of this study is to gage the effect of hybridization of natural and glass fibers reinforced polypropylene using extrusion technique. The conclusions based on this study are as follows:

1. It was found that a threshold temperature was 50^{0}C, below this temperature the mechanical strength is reduced while higher that this temperature, the mechanical strength is increased.
2. The composite strength increased when the fiber volume fraction is increased especially at higher temperatures.
3. From the SEM observation, it was found that the bonding compatibility between natural fibers and the matrix was very poor but addition of glass fibers give an advantage of increasing the composite strength.
4. Glass fiber worked as micro-toughening effect in the composite to prevent sudden failure.

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