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Mechanical Properties of Hybrid Polymer Composite Using Natural Fiber and Nanoparticle

C. W. Kai, A.H. Abdullah, S. Debnath*

Faculty of Science & Engineering, Curtin Malaysia, Miri, Sarawak, Malaysia

*Corresponding Author: d.sujan@curtin.edu.my

Abstract.

Hybrid polymer composite were prepared by incorporating two indigenous agro-industrial waste reinforcements, sugarcane bagasse fiber (SBF) and coconut coir fiber (CCF) into epoxy resin through the hand lay-up technique. Nano-silica was also added to enhance the mechanical performance of composite materials. The alkaline treatment on the surface of natural fibers was carried out and its effects on the mechanical properties were investigated. Generally, it is found that the CCF reinforced epoxy composites exhibited higher mechanical properties as compared to the SBF reinforced epoxy composites. For hybrid composite samples, (2.5wt%SBF+12.5wt%CCF) had attained the highest mechanical performance amongst all other different ratio percentage of hybrid polymer composite.

1. Introduction

Conventional polymers unable to display different characteristic and properties that is required in the present modern day engineering applications. Therefore, hybrid polymers are absolutely gaining the opportunities in material science processing and production [1]. It is a high chance that hybrid polymer will replace the single material of polymer or conventional polymer.

In order to fulfill ecological and economic benefits, researchers put in a lot of effort into development and creation on high performance and strong hybrid polymer reinforced by using natural fiber and nanoparticle. Due to extraordinary mechanical properties, natural fiber reinforced with nanoparticles have shown their better potential to be used as an alternative material in replacing synthetic fiber [2]. However, there are difficulties faced by natural fiber polymer composites such as interfacial adhesion bonding between fiber and binding matrix [3]. This issue would lead to the problem of agglomeration and it would create poor stress transfer efficiencies.

Natural fibers have more advantages than synthetic fiber, so it has become the alternative solution that would apply in several reinforcement material industries [1-5]. The finding of this study will contribute to the benefits of society considering that natural hybrid polymer plays important role in the improvement of mechanical performances of composite materials. From this research is studying the effectiveness utilization of natural fiber (sugarcane bagasse fiber and coconut coir fiber) that embedded into epoxy resin. The incorporation of sugarcane bagasse fiber and coconut coir fiber are proven to enhance the mechanical properties of epoxy composites. In order to make further



improvement on the quality, silica is introduced as additional nanoparticle into reinforcing materials as the purpose is to reduce the voids in composite materials.

2. Method

2.1. *Preparation of Samples*

SBF and CCF were first rinsed and washed by using clean water and dried at 80°C by using an oven for 24h. The fibres were treated with 5% concentration alkaline solution. Then, the fibres were immersed into 5% concentration of sodium hydroxide (NaOH) for 5 hours at room temperatures. Subsequently, the fibres were washed with distilled water. Finally, the fibres were dried in an oven at 80 °C for 8 hours. Then the polymer composites were prepared by hand lay-up technique by mixing the SBF/CCF with the epoxy resin and stirred thoroughly for 5 minutes until the filler was completely mixed with the resin. Next, the mixture was degasified using a vacuum oven. After that, the mixture was poured into the mould and left for solidification. After solidification, composites were post-cured in an oven for 2 hours at 80°C.

2.2. *Tensile & Flexural Test*

Tensile and flexural testing was carried out in accordance with designation ASTM D638 and ASTM D790 respectively, by using LR Plus LLOYD Universal Testing Machine.

2.3. *Water Absorption Test*

Water absorption test were carried out to measure the amount of specimen immersed in water under the specific standard condition which is according to ASTM D570. Specimens were immersed in the water condition with 23°C for 24 hours. After 24 hours, specimens are being removed and dried in the oven with 50°C for 5 hours, and let it cool inside the desiccators until they reach the room temperature. For this procedure is to get the initial weight as the base reference of the specimens. For every 24 hours, specimens are removed from the water and wiped off the surface with a dry cloth in order to weighting system. Next, there are continues for conduct the testing with immersed specimen into distilled water for continue 14 days in order to achieve the weight percentage increase in specimen due to water absorption.

3. Result and Discussion

Figure 1 and Figure 2 show the tensile strength and tensile modulus of composites materials versus the natural fiber content. Amongst 5wt% of natural fiber reinforced composite, 5wt% CCF showed the highest tensile strength which is 41.014MPa with increment of 189.7%, while it has the highest Young's Modulus of 1457.8MPa with increment of 239.8%. Along with others natural fiber reinforced composite of 5wt% SBF, there is having similar value of Ultimate Tensile Strength and Young's Modulus with result of 36.079MPa and 1381.8MPa. It has the difference of 1.4% difference for both Ultimate Tensile Strength and Young's Modulus when compare to reference sample.

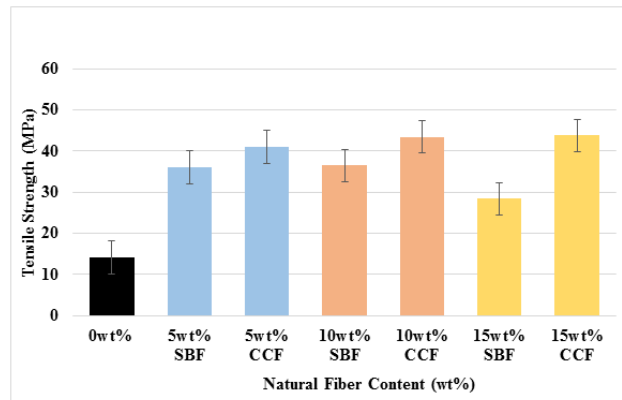


Figure 1. Tensile Strength vs Natural Fiber Content

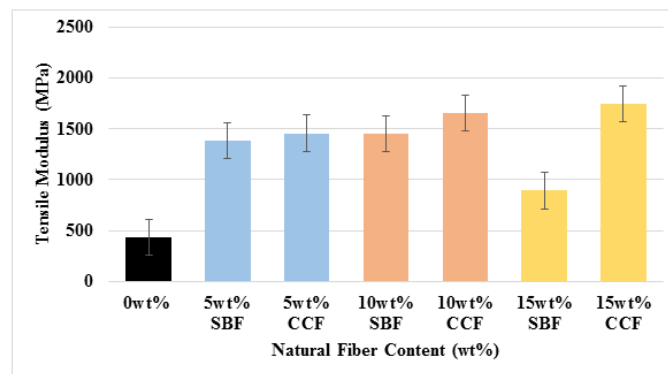


Figure 2. Tensile Modules vs Natural Fiber Content

For the combination of 10wt% natural fiber reinforced composite, 10wt% CCF has the highest tensile strength which is 43.404MPa with increment of 206.6%, while it has the highest Young's Modulus of 1657.8MPa with increment of 286.5%. Compare between 10% SBF and reference sample, there is having similar pressure rate of tensile strength of 36.445MPa with 2.9% difference while Young's Modulus is 1452MPa with only 5.6% difference. Between the combinations of 15wt% of natural fiber reinforced composite, 15wt% CCF obtain the highest tensile strength which is 42.487MPa with increment of 200.2%, while it has the highest Young's Modulus of 1745.1MPa with increment of 306.9%. Along with 15wt% SBF, it was gain the pressure rate of tensile strength with 28.343 MPa and Young's Modulus with 892.6MPa. Compare between 15% SBF and reference sample, the Ultimate Tensile Strength is 28.343MPa with only 2.9% difference while Young's Modulus is 1452MPa with 5.6% difference. From all the results above show that single component of natural fiber with content of CCF give the best result when compare to SBF. It is because the CCF has high content of cellulose which provides tensile strength.

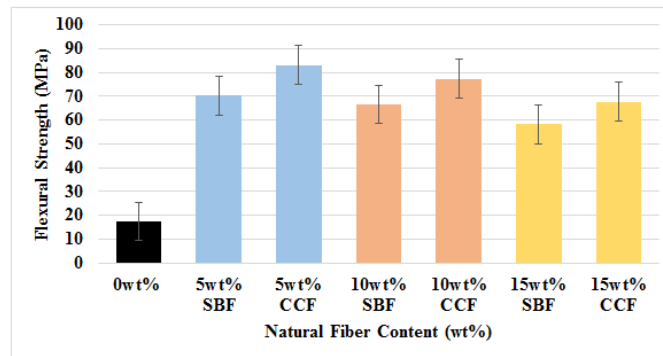


Figure 3. Flexural Strength vs Natural Fiber Content

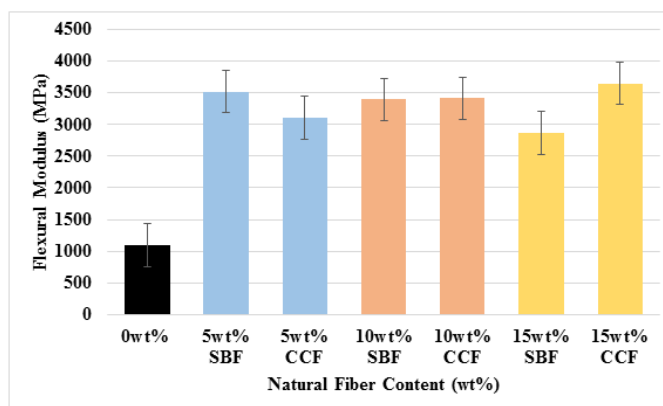


Figure 4. Flexural Modulus vs Natural Fiber Content

Figure 5 and Figure 6 shows the UTS and Modulus for hybrid composites. Amongst the entire hybrid polymer composite samples, (5wt% SBF+5wt% CCF) showed the highest UTS (37.505MPa) and modulus (1534MPa).

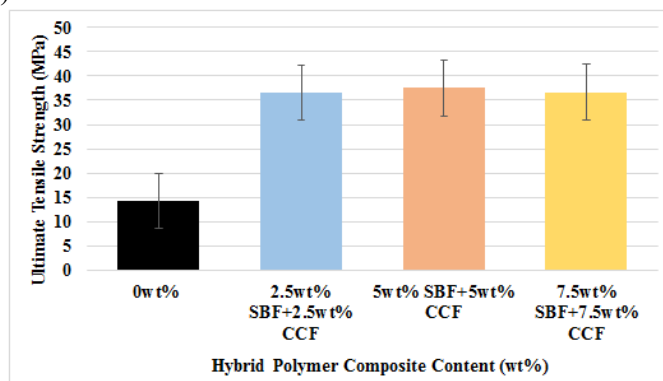


Figure 5. UTS of hybrid polymer composites

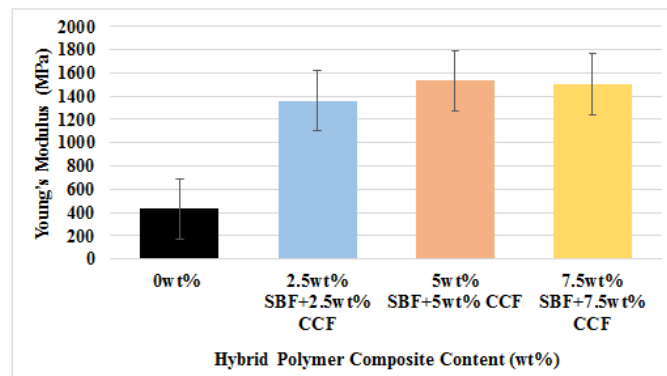


Figure 6. Modulus of hybrid polymer composites

Figure 7 and Figure 8 shows the UTS and Modulus for hybrid composites with 15wt% fibre content with different SBF and CCF ratio. It can be seen that (2.5wt%SBF+12.5wt%CCF) give the best result in Ultimate Tensile Strength with 39.329MPa and Young's Modulus of 1411.1MPa. Higher percentage of CCFs would provide more strength to the hybrid composites. In order to increase on UTS, there is important that to increase the weightage percentage of CCF into hybrid polymer composite.

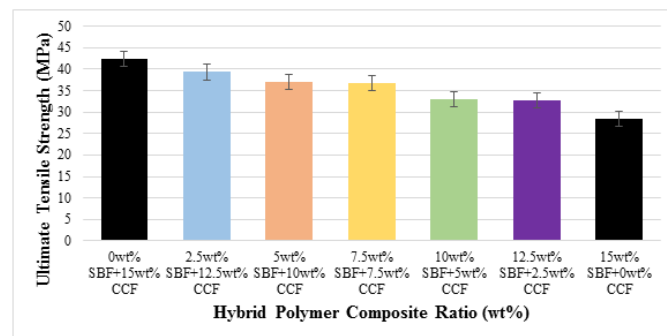


Figure 7. UTS of hybrid polymer composites

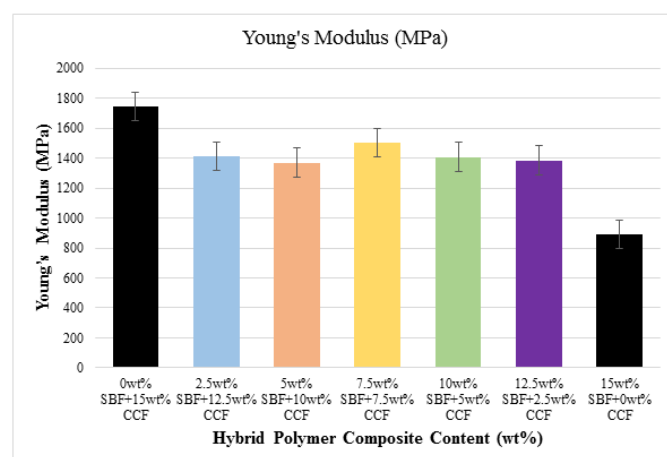


Figure 8. Modulus of hybrid polymer composites

Figure 9 and Figure 10 shows the flexural strength and flexural modulus for hybrid composites with 15wt% fibre content with different SBF and CCF ratio. The (2.5wt%SBF+12.5wt%CCF) hybrid composite samples has the highest result in flexural strength with 71.787MPa. Flexural Modulus is

slightly decreased with the result collect with 3450.5MPa. For comparison between reference samples of (0wt%SBF+15wt%CCF) composite, Flexural Strength of (2.5wt%SBF+12.5wt%CCF) composite showed higher value with increment of 6%, but there is slightly decrease on Flexural Modulus by 5%. This is due to the fact that SBF has better efficiency stress transfer between two components. SCB has the properties of high porosity with the inferiority.

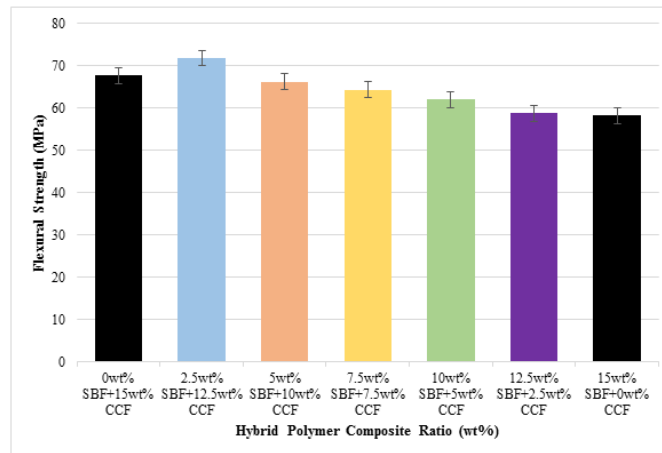


Figure 9. Flexural Modulus vs Natural Fiber Content

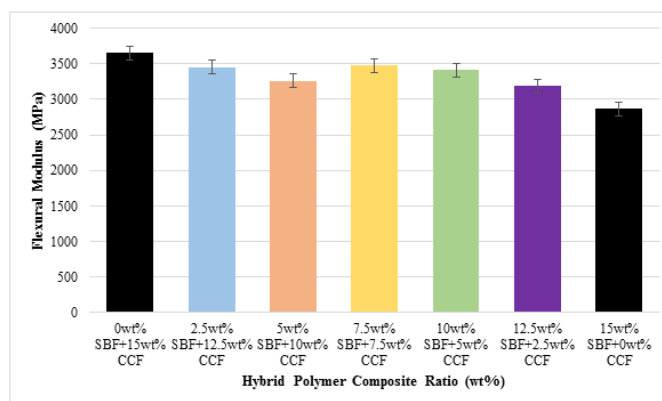


Figure 10. Flexural Modulus vs Natural Fiber Content

Figure 11 shows the moisture uptake for hybrid polymer composites. It is observed that all of the natural fiber composite and hybrid polymer composite are steadily increase with the samples immersion time. It is determine that highest percentage of weight increase is 15wt% SBF with 4.22%. The least of weight increase is reference sample of 0wt% with weight increase which is 1.23%. This is means that the least weight increase for the hydbrid polymer composites is 5wt% CCF with 1.82%. From the result shown above, it can be seen that 15wt% SBF has the increment of 243.1% when compare to reference sample, while 5wt%CCF has the increment of 47.9%. It can be concluded that when there is higher content of natural fiber reinforcement in hybrid polymer composites, the water uptake will increase. It is due to the fact that, both SBF and CCF have the component of hemicellulose. The CCF has lower hemicellulose content which are only 7.95wt% while SBF has higher percentage of hemicellulose with 28.6%.

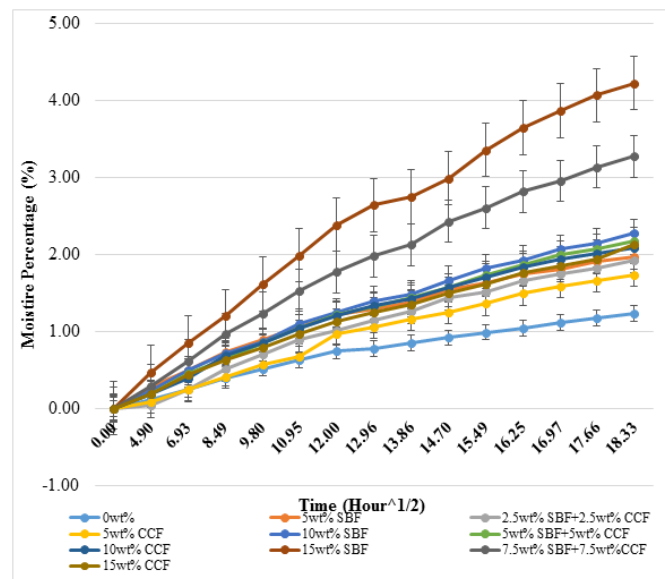


Figure 11. Moisture uptake for hybrid polymer composites

4. Conclusion

Natural fiber reinforced epoxy resin composite had perform better mechanical performance (tensile properties and flexural properties) when compare to pure epoxy resin composite. Among all single natural fiber reinforced epoxy resin composite, Coconut Coir Fiber performs higher result than Sugarcane Bagasse Fiber in mechanical performance (Tensile properties, Flexural properties and Moisture properties). The (2.5wt%SBF+12.5wt%CCF) hybdrd composite samples had attained the highest mechanical performance amongst all other different ratio percentage of hybrid polymer composites.

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