Mechanical Properties of Treated Powder Bamboo/Short E-Glass/Polypropylene Hybrid Composite

Kannan Rassiah
Politeknik Port Dickson
kannan@polipd.edu.my

Noor Hasanah Tham Shu Yin
Politeknik Port Dickson
hasanah@polipd.edu.my

Mohd Ghazali Kadir Sulaiman
Politeknik Port Dickson
ghazali@polipd.edu.my

Abstract
Natural fiber reinforced composites are necessary in demand to growth use of polymer composite technology. The key goal of this research to exploits bamboo species (*Gigantochloa Scortechinii)*, which was collected from the Melaka, Malaysia. The treated bamboo fiber were sieve average to 500 μm and divided into 10 composition ratio through 6 mm short (EG) E-Glass fiber and(PP) polypropylene. The hybrid composites were processed in internal mixer and hot-press with 50 to 95 percentage polypropylene ratio and were characterized in term of mechanical properties. The behaviour of impact strength, tensile strength, and flexural strength improved in 2.5 % (TB) treated bamboo however opposite for thehardness value, tensile modulus, and flexural modulus with 25 % (TB) treated bamboo composition respectively. The morphology (SEM) scanning electron microscopy results support the mechanical properties which showed the interaction between PP/EG/TB with the selected composition. Overall, the treated bamboo/E-Glass/Polypropylene hybrid composites indirectly can reduce the use of polypropylene in the production of products.

Keywords: Treated, hybrid composite, *gigantochloa scortechinii*

1.0 Introduction

According to earlier studies that humidity causes degradation or decrease of the mechanical properties of natural fiber reinforced composites to a greater range than synthetic fiber reinforced composites, due to the rate high absorption, and organic fiber properties (Rassiah & Megat Ahmad, 2013 a&b). It is required to reduce the hydrophilic properties of natural fibers through chemical treatments with coating through appropriate resin or by agent coupling to improve mechanical properties and environmental impact to be better. The composites made of natural fiber have potential in the sport industries, automotive, construction, and aerospace (Davoodi et al., 2011; Bledzki et al., 2006).

Hybridization of natural fibers with synthetic fibers is corrosion-resistant and stronger, for example, carbon or glass fiber, can furthermore increase the strength, and resistance of composite humidity. When using a hybrid composites containing two or more different fiber types, the advantages of one type of fiber can complement the lack of other fiber properties. As a result, balance in performance and cost can be achieved through the correct material design method. The bamboo fiber composites are likely to be naturally superior to glass fiber composites in most applications due to lower green impacts and have higher fiber content for comparable performance (Tripathi & Yadav, 2017). Bamboo is a raw material which has been used in low-cost bridges, construction platforms, and houses (Bahari & Krause, 2015). The presence of bamboo as a natural composites performance the applications, such as in the bicyclist helmets, aircraft sand vehicles, and decks for leisure activities (Ibrahim et al., 2015; Mahdavi et al. ,2012; Qiu et al.,2013). Besides that, according to Gutu, (2013) the strength properties of bamboo are higher than most of the soft and hard woods. Bamboo is a sustainable natural fibers, which can grow very fast per day, and have an excellent mechanical performance (Sanal, 2016).

Therefore, the mechanical properties of bamboo fiber hybrid and glass fiber composites in the polypropylene matrix (PP) which are subjected to mechanical properties have been studied, considering the effects of fiber length, fiber content, and coupling agent.

2.0 Material

The materials used in this study are (PP) "Polypropylene" as the matrix, (EG) E-glass as well as strengthening of (TB) treated bamboo fibers. Table 1 show the composition ratio of PP/EG/TB hybrid composite.

2.1 Polypropylene

Polypropylene TITANPRO 6331 with melt flow index 5 and density 0.9 g/cm^3 Figure 1, and maleic anhydride (MA) with density of 0.902 g/cm^3 was used for this study.

2.2 E- glass

E glass fiber Figure 2 with a length of 3 mm is obtained by cutting of continuous fiber using a electronic cutting machine.

2.3 Bamboo

Bamboo is obtained in the area of Kampung Bukit Larang, Melaka Malaysia. Above the third clum from the base of the bamboo is cut. Then the bamboo is cut in between the segments. The fiber between inner and outer part of the bamboo is taken and cut to a length and width 120mm and 10mm respectively Figure 3.

Figure 1: Polypropylene(PP)

Figure 2: E-glass fiber

Figure 3: Bamboo fiber

2.4 Treated bamboo preparation

Soak bamboo in water for 2 days. After that, the bamboo strip is poured and boiled in water with boiling temperature 100° C for 30 minutes. The boiled bamboos are outlined to get a diameter of 1mm and dried in the oven with temperature 80° C for 2 hours and 60° C for 24 hours. Next, the bamboo fiber are cut in 10mm long and immersed in sodium hydroxide (NaOH) with 1.5N solution for 10 hours and washed in water until the pH

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value becomes 7. Then the bamboo fiber is put into oven at 90° C for 72 hours to dry. Finally, the treated bamboo fiber will be blended using a blender machine and sifted to obtain the size of bamboo fiber<500 µm. Figure 6 show the flow of treated bamboo, while Figure 4 and 5 the bamboo surface morphology before and after treatment.

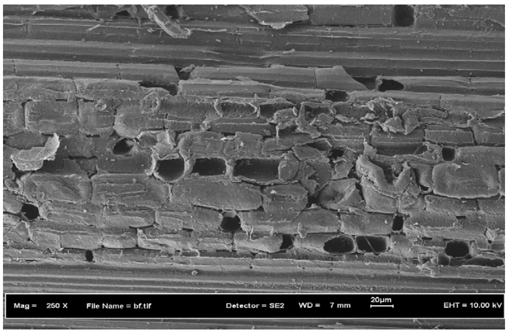


Figure 4: Bamboo before treatement

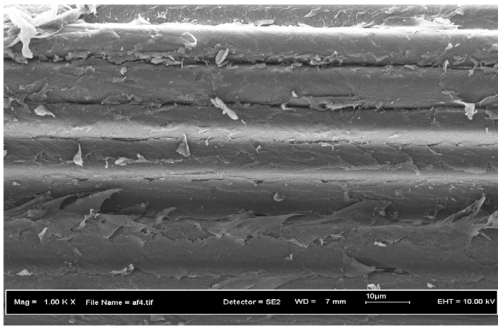


Figure 5: Bamboo after treatement

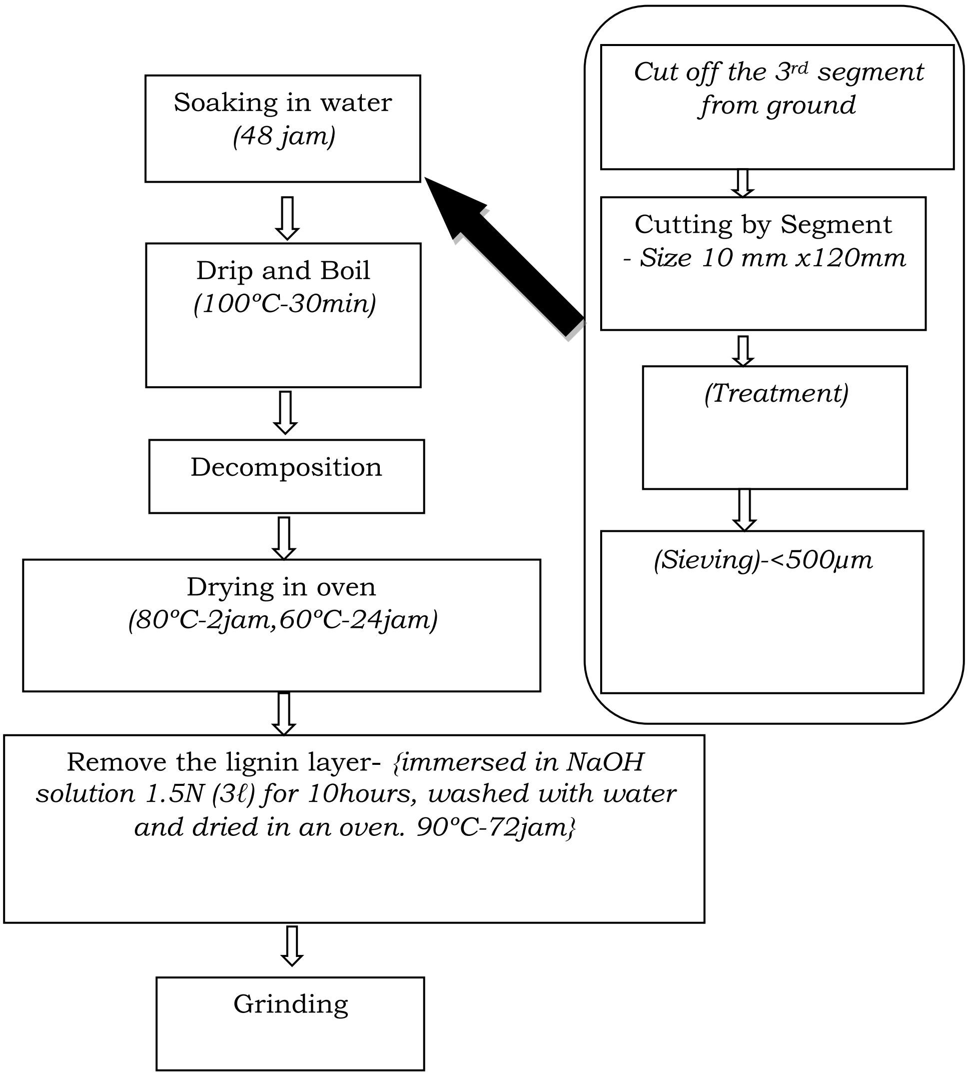


Figure 6: Flow chart of treated bamboo

Table 1: Composition ratio of polypropylene, bamboo & e- glass fiber with MAPP

Polypropylene Matrix	Synthetic fiber E-Glass (6 mm)	Treatedbamboo (Micro) <500 μm	Coupling Agent Maleic anhydride
PP(100%)	-	-	-
PP (95%)	2.5%	2.5%	1 phr
PP (90%)	5%	5%	1 phr
PP (85%)	7.5%	7.5%	1 phr
PP (80%)	10%	10%	1 phr
PP (75%)	12.5%	12.5%	1 phr
PP (70%)	15%	15%	1 phr
PP (65%)	17.5%	17.5%	1 phr
PP (60%)	20%	20%	1 phr
PP (55%)	22.5%	22.5%	1 phr
PP (50%)	25%	25%	1 phr

3.0 Experiment

The three main ingredients, PP matrix, E-glass fiber and bamboo fiber are blended into Thermo Haake Rheomix 600 OS Internal Mixer machine. The machine is set to mix for 10 minutes. Polypropylene is inserted first and left for 2 minutes to dilute. After that, E-glass fiber is inserted for 3 minutes. Then, the bamboo fiber is inserted for a further 5 minutes. After these ingredients have been mixed in the Internal Mixer and left to harden at room temperature for 5 minutes, the mixture is put into a crusher machine. This machine will crush the mixture into a uniform size so that it can easily be placed into the Hot Plate during the heat press. The hot press process is carried out at 190°C for 6 minutes under 20 Tons load. The mixture is then cooled for 6 minutes on the cooling part of the hot press machine. The resulting plate is 250 mm x 250 mm x 3 mm. The plates are cut according to size for mechanical tests conducted according to ASTM standards. Figure 7 shows a schematic for the heat press process.

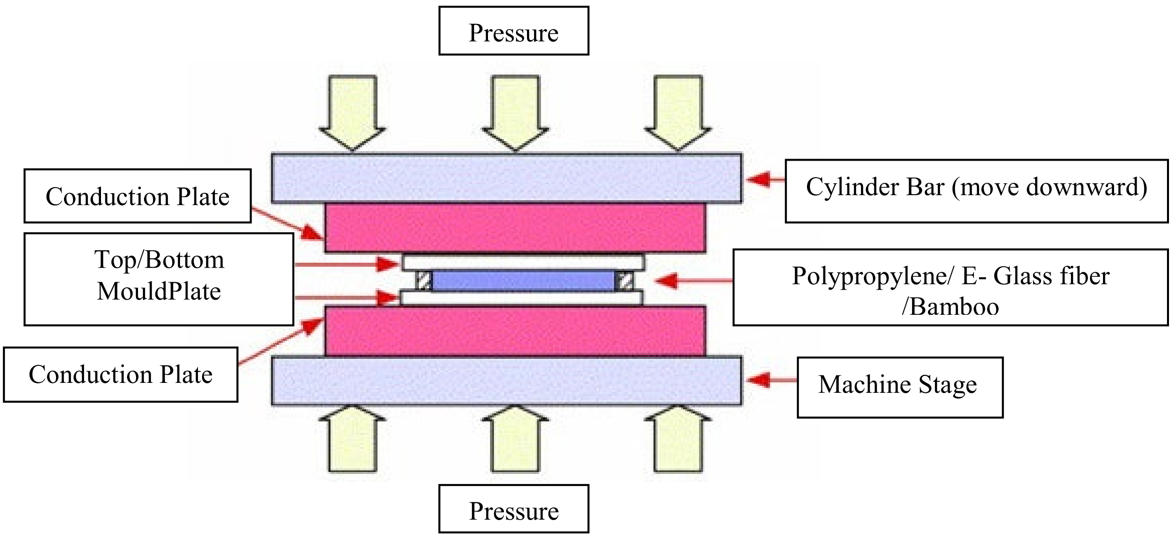


Figure 7: Schematic of hotpress

3.1 Mechanical testing

a. Tensile testing

The tensile test was carried out by providing experimental samples with a size of 60 mm x 12 mm x 3 mm for gauge length based on ASTM 638. Long samples at the ends of the sample were measured and marked before hand to obtain uniform measurements between the two ends of the sample. Then, the sample width is measured and marked in the center to ensure the sample will be in the center of the upper and lower grips. Instrument machines are set with a load of 50kN and a voltage of 1.5 mm / min. The test is then carried out and the sample is pulled up until it breaks. The machine was discontinued after the sample was dropped and the reading was recorded through the Blue hill software.

b. Flexural testing

This method is often used primarily for the flexural properties for quality control and for specific purposes. Measurement of this test specimen is in accordance with standards based on ASTM D790. The size of the specimen for this test is 60 mm x 12 mm x 3 mm thick in support range with support span 48 mm. The cross head speed used is 1mm / min.

c. Impact testing

Under the law of energy, the amount of force that hit the specimen equals the amount of energy absorbed by the specimen. During the charpy test, the notch is about 1/3 of the thickness of the specimen. Measurement of this test machine standard is based on ASTM D6110 with a size of 60 mm x 12 mm x 3 mm.

d. Hardness testing

The tool used for the purpose of testing the hardness of the test sample is Durometer. The durometer we use is ShoDurometer lent from UTeM FKP. Measurement of this test standard is based on ASTM D2240 with a size of 30 mm x 30 mm x 3 mm. The way to measure the Durometer is by set a readings to 0. Press the needle located at the end of the Durometer to sink into the specimen. Make sure the Durometer plate is close to the surface of the specimen. The mentioned reading is recorded. Readings are taken on five different positions, and the average reading is calculated.

e. Scanning electron microscope

The electron microscope (SEM) is used to reveal the fiber fracture effect for the test sample and also to see the surface condition of *Gigantochloa Scortechinii* bamboo before and after treatment. Scanning Electron Microscope observation was performed using Philips XL 30 ESEM operated at 10 to 30 kV. The tensile fractured samples were dried and coated with the gold using Sputter Coater Polaron E-5100 system.

4.0 Results and discussion

4.1 Tensile analysis

The treated bamboo and E-glass fiber are filled with various mixtures of polypropylene to produce hybrid composite. In general, the results showed that tensile strength of the PP/EG/TB hybrid composite decrease with the addition of E-glass and treated bamboo fiber (Figure 8). However, the tensile modulus of the PP/EG/TB hybrid composite displays different behaviour (Figure 9). The higher value of the tensile strength (Figure 8) hybrid mixture polypropylene, E-Glass and treated bamboo fiber is 25.8 MPa. Meanwhile the lowest value 15.39 MPa. This refers to the objective to find the effects of fiber length, fiber content, and coupling agent. The 6 mm E-glass fiber and 500µm treated bamboo with 1phr coupling agent result indicate that more percentage show lower value in hybrid composition. The less percentage of polypropylene cannot reinforce well with E-glass/bamboo fiber.

Meanwhile Figure 9 shows that tensile modulus value is increasing when percentages of 6 mm E-glass fiber and 500µm treated bamboo with 1phr coupling agent increased. The tensile modulus increased from 720 MPa to 1612 MPa from 2.5 % to 25 % treated bamboo respectively. The result showed that the incorporation of 6 mm E-glass fiber and 500µm treated bamboo has resulted in the increasing the tensile modulus. The effects of E-glass fiber length, treated bamboo fiber content has restricted the mobility of the matrix when load was forced onto the hybrid composite.

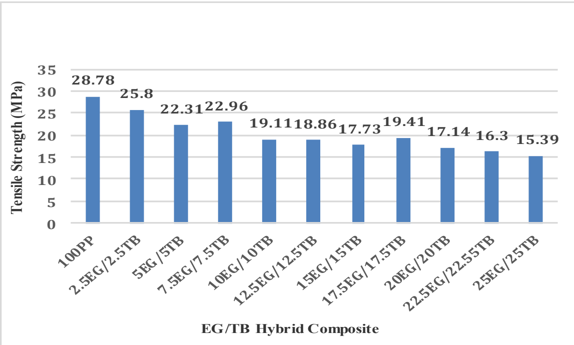


Figure 8: Chart of tensile strength against percentage of EG/TB Hybrid composite

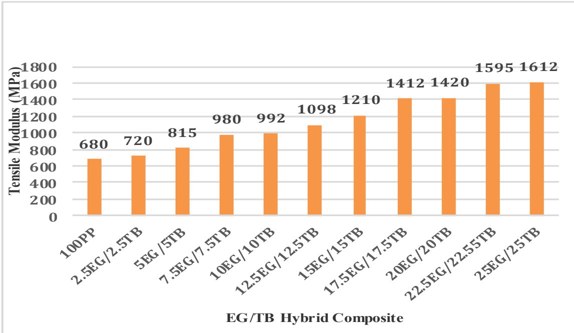
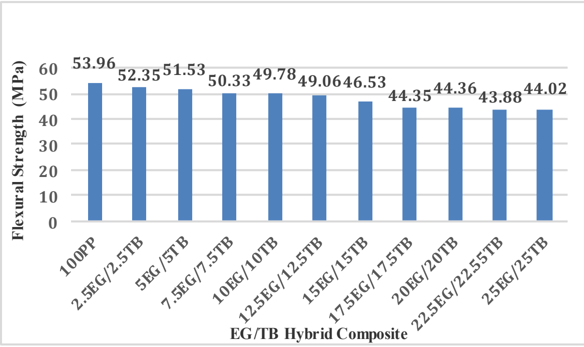
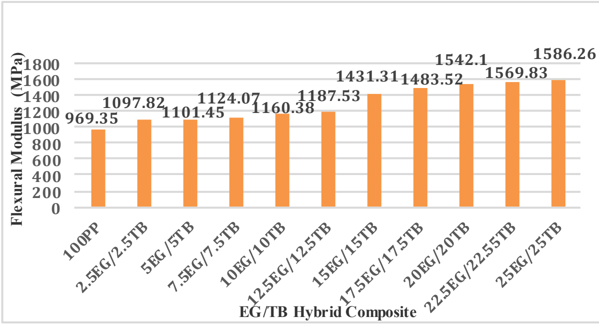


figure 9: chart of tensile modulus against percentage of EG/TB hybrid composite

4.2 Flexural analysis

Flexural test was directed to determine the ability of a material to withstand bending before hitting its breaking point. Figure 10 and 11 show





the results obtained for flexural strength and flexural modulus. The results indicated flexural strength of the PP/EG/TB hybrid composite decrease with the addition of E-glass and treated bamboo fiber (Figure 10) and the flexural modulus of the PP/EG/TB hybrid composite increase with the addition of E-glass and treated bamboo fiber (Figure 11). The higher value of the flexural strength (Figure 10) hybrid mixture polypropylene, E-Glass and treated bamboo fiber is 52.35MPa. Meanwhile the lowest value 43.38MPa. This refers to the objective to find the effects of fiber length, fiber content, and coupling agent. The 6 mm E-glass fiber and 500µm treated bamboo with 1phr coupling agent result indicate that more percentage show lower value in hybrid composition. Meanwhile Figure 11 shows that flexural modulus value is increasing when percentages of 6 mm E-glass fiber and 500µm treated bamboo with 1phr coupling agent increased. The flexural modulus increased from 1097.82MPa to 1586.26MPa from 2.5 % to 25 % treated bamboo respectively. The result showed that the incorporation of 6 mm E-glass fiber and 500µm treated bamboo has resulted in the increasing the flexural modulus.

Figure 10: Chart of flexural strength against percentage of EG/TB hybrid composite

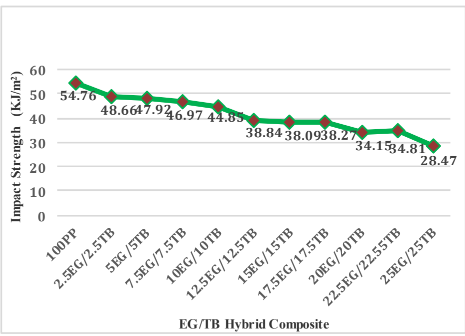
Figure 11: Chart of flexural modulus against percentage of EG/TB hybrid composite

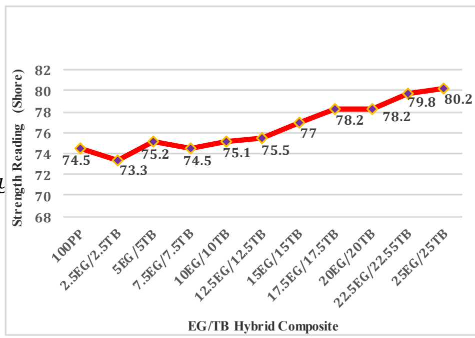
4.3 Charpy impact analysis

The impact strength of the hybrid composite PP/EG/TB is presented in Figure 5. Figure 5 shows the impact strength of 2.5% EG & 2.5% TB hybrid mixture is higher than other hybrid mixtures. The impact strength of 6 mm E-glass fiber and 500µm treated bamboo hybrid composite at 2.5% EG & 2.5% TB and 25% EG & 25% TB were 48.66 KJ/m^2 and 28.47 KJ/m^2. The figure also shows the impact strength is reducing when percentages of 6 mm E-glass fiber and 500µm treated bamboo with 1phr coupling agent increase in hybrid composite.

4.4 Hardness analysis

The high hardness value of the mixture displays the property of the material, which has high hardness level. The hardness value of pure





polypropylene and percentages of 6 mm E-glass fiber and 500μm treated bamboo with 1phr coupling agent hybrid composition are calculated and shown as in Figure 6. The hardness strength reading of hybrid composite 2.5 EG/2.5TB is 73.3 HV, 12.5EG/12.5TB is 75.5 HV and 25EG/25TB is 80.2 HV respectively. It can be seen from the result obtained that hardness of 6 mm E-glass fiber and 500μm treated bamboo with 1phr coupling agent increase when the percentage increase in hybrid composite.

Figure 12: Chart of impact strength against percentage of EG/TB hybrid composite

figure 13: chart of strength reading against percentage of EG/TB hybrid composite

4.4 Scanning electron microscope

The investigates towards surface morphology of the broken specimens conceded out by using scanning electron microscope after the tensile testing. Figure 14 and 15 shows the results. Its show that stress cracking can be considered to occur along the fiber. The interface of the E-glass fiber and the matrix is weak. Occurrences of long fractures and cavities in the interface adhesion area cause composite density to be lower when the number of E-glass fiber and bamboo fiber composition increases. Similar results were reported by Banga et al (2015), presence of pores and voids in the composite material considerably affect the performance of the composites structure. It is a fact that less percentages of treated bamboo and E-Glass can advances the fiber surface bond exclusivity by removing hemicelluloses and producing rough surface in hybrid composite.

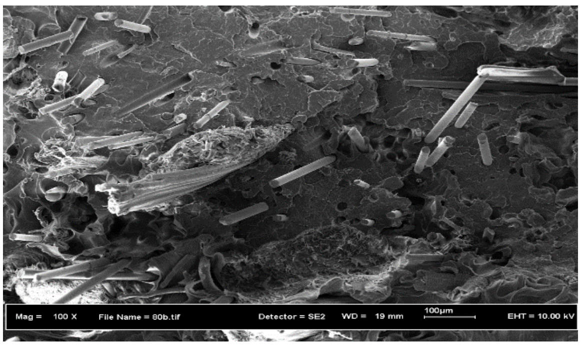


Figure 14: Magnification at mixture of 80 wt. % PP, 10 wt. %EG and 10 wt. 10% TB

Figure 15: Magnification at mixture of 50 wt. % PP, 25 wt. %EG and 25 wt. 10% TB

5.0 Conclusions

Based on the mechanical properties results, filling of treated bamboo (Micro) <500 μm and 6 mm E-Glass fiber length with coupling agent in polypropylene ratio shows the different rates of mechanical testing results. Founded on the observation, the results show that tensile strength, impact strength and flexural strength decrease with the increase in the ratio percentages of PP/EG/TB. In the meantime, for the hardness strength, tensile modulus and flexural modulus increase as the percentages of E-Glass and treated bamboo fiber/polypropylene hybrid composite increases. This can indirectly reduce the use of Polypropylene in the production of products that require the nature of hardness and ability to absorb energy, for example home panelling and furniture.

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