Effect of synthetic fibres on tensile properties of Napier fibres reinforced epoxy composites

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Abstract. This paper present the effect of synthetic fibres on the tensile properties of Napier fibres reinforced epoxy composites. The composites were fabricated using the vacuum infusion method, which the Napier grass fibre placed between the synthetic fibres, then mixed the epoxy resin with a ratio of fibres and epoxy was 70:30. There were four different types of composite samples were fabricated based on various volume fractions. The samples were manufactured using vacuum infusion process. The composites are tested using a universal testing machine according with ASTM standard D638. The tensile strength of the hybrid synthetic/Napier fibre reinforced epoxy composites increased as the content of the synthetic fibre content increased. The tensile properties of the hybrid carbon/Napier reinforced epoxy composites were observed higher than the hybrid glass/Napier reinforced epoxy composites.

1. Introduction
The rising concern towards environmental issues and global warming affects nowadays have been driven the researchers to examine the use of sustainable material as a substitute for regular polymer composites fabricated with engineered filaments which is synthetic fibres, such as aramid, glass and also carbon [1–4]. On the other hand, the natural fibres show extraordinary potential over synthetic fibres in view of their biodegradability, low cost, low density, and satisfactory specific properties [5,6]. Carbon fibre is most prominently used to strengthen composite materials, especially the class of materials known as carbon fibre and graphite reinforced polymers [7]. The diameter of the carbon fibre material is about 510 µm and generally made out from particles which is carbon atoms. This particles are bonded together along the parallel axis of the material fibre which gives higher strength depends on its size. This paper present the effect of synthetic fibres on the tensile properties of Napier fibres reinforced epoxy composites.
2. Materials and Method

2.1. Materials

The composites are the combining of Napier fibre and synthetic fibre which being prepared as a sandwich structure in dimensions of 320 x 300 x 0.1 mm per layer, thus fabricated using the vacuum infusion method. The Napier grass is a part of Napier species which required small amount of nutrients supplement to growth where harvested from a local plantation located at Bukit Kayu Hitam, Kedah, in Northern Peninsular of Malaysia [8]. The carbon and glass fibres was supplied in form of woven roll which offered high strength and stiffness. The matrix material, EpoxAmite 100 series resin was mixed with the slow hardener to a ratio of 3:1 as specified by the manufacturer.

2.2. Extraction of Napier Grass Fibre

The Napier grass fibres were extracted by using a conventional water retting process. Water retting is a microbial process that produces homogenous and high-quality fibre, where the stems are immersed in water tanks, and their progress being monitored daily. Prior to retting, the Napier leaves are removed from the internodes of each stem. Initially, the stems are cleaned and crushed with a mallet before immersed under tap water for approximately three to four weeks, for separation and decomposition process. The fibres are then manually extracted from the stem internodes up to the removing the excessive cellulose from the fibre.

2.3. Hybrid Composite Fabrication

The hybrid synthetic/Napier reinforced epoxy composite laminates are fabricated by a resin infusion technique powered by a vacuum pump which familiarly called as vacuum infusion process [9]. First step is by preparing a sandwich structure for this hybrid synthetic/Napier fibres reinforced epoxy composite, where the Napier grass fibre is placed as a core between the carbon fibre, which is layering on the upper and bottom faces of the sandwich structure. Then, the reinforcement plies is laminated over a glass mould. After settling the arrangement of materials over the composite as shown in the schematic of the vacuum infusion process, the resin then infused into the lamination plies.

2.4. Tensile Test

The composites are tested using an electronic extensometer to measure the tensile properties of the hybrid composite vary with various volume fraction. An INSTRON micro-tester with a 250 kN load cell is utilized, and the samples are tested at a crosshead speed of 0.5 mm/min. The specimens is prepared according to ASTM D638 standards where, each of the specimens are machined to dimensions of 165 x 19 x (3.2±0.4) mm³ with a gauge length of 115 mm for accurate strain measurement [10]. Five identical test specimens were used for each sample in this experiment. The result for tensile strength and modulus of the hybrid composite were achieved and recorded for analysis.

3. Result

3.1. Tensile Strength

The tensile strength of hybrid carbon/Napier epoxy composites and hybrid glass/Napier epoxy composites is obtained as shown in Figure 1. The figure shown clearly indicates that the tensile strength of the hybrid composite is significantly improved with the incorporation of the carbon fibre compared with the incorporation with the glass fibre. For Sample So, the tensile strength was observed by 21.09 MPa which functioned as a reference for both hybrid composites. Thus, Figure 1 shows that the tensile strength of the hybrid carbon/Napier epoxy composites were obtained by 103, 162, 245 and 316 MPa for S1, S2, S3 and S4 respectively. The tensile strength of the hybrid carbon/Napier epoxy composites increased as the volume content of the carbon fibres increased. Therefore, this strength
degradation trend was measured in percentages (%), thus represents strength increment by 142, 121, 124, and 143%, respectively for S1, S2, S3 and S4 results of hybrid glass/Napier epoxy composites compared with hybrid carbon/Napier epoxy composites. This shows that the hybridization with the carbon fibre improved the tensile strength of the hybrid composites compared with glass fibre.

Figure 1. Tensile strength of hybrid synthetic/Napier reinforced epoxy composites

3.2. Tensile Modulus

The tensile modulus of hybrid carbon/Napier epoxy composites and hybrid glass/Napier epoxy composites is obtained as shown in Figure 2. There are slight difference with the tensile modulus between hybrid carbon/Napier epoxy composite and hybrid glass/Napier epoxy composite depending on the line graph. Whereas the tensile modulus of Napier fibres reinforced epoxy composites (So) increased from 1.72 to 6.18 GPa with a content of 6% volume fraction of carbon fibre (S1), representing an increase of 259% compared with the content of 6% of glass fibre (S1) by 88% of increment from 1.72 to 3.22 GPa. The tensile modulus of the hybrid carbon/Napier epoxy composites also increased by 8.4, 10.4 and 11.47 GPa for S2, S3, and S4 samples, respectively. This represent strength reduction of hybrid glass/Napier epoxy composites by 48, 37, 27, and 20% for S1, S2, S3 and S4 samples, respectively compared with the result of sample hybrid carbon/Napier epoxy composites. Therefore, the carbon fibre resulted higher stiffness in the reinforcement of hybrid composites compared to the glass fibre.
Figure 2. Tensile modulus of hybrid synthetic/Napier reinforced epoxy composites

4. Conclusion
The conclusion obtained based on the experimental results. The tensile strength of the hybrid synthetic/Napier fibre reinforced epoxy composites increased as the content of the synthetic fibre content increased, thus strengthening the interfacial bonding between the fibres and the epoxy of the composites. Therefore the larger load was required to break the interlocking structure of the hybrid composites. The tensile strength of the hybrid carbon/Napier epoxy composites were observed higher than hybrid glass/Napier epoxy composites. Obviously, the carbon fibre was point out to be well performance of the tensile strength compared to glass fibre.

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