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Full Length Research Paper

Tensile characterization of hybridized snail shell filler/glass fibre epoxy composite

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ABSTRACT: Studies into the use of eco-friendly materials in composite production have been conducted, because of the environmental risks posed by synthetic materials. In this study, the tensile characterization of a snail shell filler/glass fiber composite was evaluated. During the composite production, glass fiber was partially replaced with 2, 4, 6, 8, and 10% wt. (percent) snail shell filler. The hand lay-up method was used to create all of the composite samples. The tensile properties of the produced composite samples were evaluated in accordance with the ASTM International standard. The filler volume had a significant impact on the composite samples' tensile strength and tensile elongation, according to the test results. The maximum tensile strength and tensile length were achieved with a shell filler volume of 4%wt snail, whereas the lowest tensile strength and tensile extended volume were achieved with a shell fill volume of 10% wt. Results of the study have shown that the small volume of snail shell filler is promising and that it can be used to replace glass fibers with potential applications in the field of green composites.

Keywords: Glass fibre, green composite, partial replacement, snail shell, tensile properties

INTRODUCTION

Composites are made up of a matrix and reinforcement material(s) that are designed to work together to provide synergistic properties of the matrix and chosen reinforcement material (s). Composites formulation and production have advanced to the point where they have a wide range of engineering properties and are thus widely used in a variety of engineering applications. Natural or synthetic materials can be used in composite production; however, the use of natural materials in composite production is being advocated for due to their environmental friendliness (Edafiadhe et al., 2019). According to Mohanty et al. (2005), natural materials have biodegradability, lightweight, availability, and recyclability characteristics; thus, substituting them for synthetic materials will not only clean the environment but will also reduce the hazardous effects of climate change caused by the use of synthetic materials. The use of two or more different materials in the production of a composite to improve the mechanical properties of the composite produced is known as hybridization. Several researchers have used natural materials as reinforcement in the production of hybridized composites. According to Kalam et al. (2005), a low volume (less than 30%) of oil palm fruit bunch fibre (OPFBF) improved the tensile properties of the composite produced from it. Similarly, composites made from Arengapinnata fiber revealed that the sample made with 10% woven roving fiber had the highest flexural strength (Sastra et al. 2005). In their study, Oghenerukevwe and Uguru (2018) found that the transverse rupture strength and bending modulus of Sawdust/Oil bean shell reinforced epoxy composites increased as the filler volume increased from 10% to 50%. Siddika and Sharif (2015) looked into the mechanical properties of a hybridized Areca/Waste Nylon Fiber reinforced Polypropylene composite. Siddika and Sharif (2015) discovered that increasing the fibre volume increases the flexural and impact strength of the composites. Furthermore, Akram et al. (2013) investigated the mechanical properties (hardness, tensile strength, torsion strength, and impact strength) of $Al2O_3$, $CaCO_3$, SiO_2, PbO, and E-Glass reinforced Epoxy composites and discovered that the mechanical properties of the composites were greatly influenced by the volume of the fillers. Because snail shell filler contains a high percentage of calcium carbonate ($CaCO_3$), it is used as a substitute for synthetic materials. Bayode et al. (2017) investigated the effect of snail shell filler on the mechanical properties of polyester composites and discovered that the snail shell filler had a significant effect on the mechanical properties of the produced composite. According to Bayode et al. (2017), among the composite samples produced, the composite reinforced with 20 wt percent snail shell filler demonstrated the best mechanical performance. Similarly, Uguru and Oghenerukevwe (2021) reported that adding a small amount of snail shell filler (6%) to $CaCO_3$ reinforced epoxy composite samples improved their mechanical performance (properties). In contrast, Kolawole et al. (2019) investigated the effect of snail shell filler on epoxy composite and found that the tensile and flexural properties of the composite produced decreased as filler content increased. Despite the fact that several works had been reported on the mechanical properties of snail shell filler reinforced composites, a literature search revealed no recorded literature on the tensile characteristics of treated snail shell filler/glass fiber hybridized epoxy composite. As a result, the goal of this research is to look into the effect of snail shell filler on the tensile properties of glass fiber reinforced epoxy composite.

MATERIALS AND METHODS

Materials

Matrix

Epoxy resin (LY556) and hardener (HY951) were the matrix materials used for the composite production. Epoxy hasgood adhesion properties, strength, toughness and resistance to chemical attack (Mohammed and Reddy, 2015). The resin and hardener were mixed at a ratio of 7:3, to produce the matrix used for the composite production.

Reinforcement materials

The pulverization snail shell and glass fibre were the two main reinforcement materials used for the composite production

Methods

Pulverization and treatment of the snail shells

The dried snails were pulverized using plate mill and sieved with a 150 µm gauge stainless steel sieve. Then the filler obtained was chemically modified with 5% sodium hydroxide (NaOH) for 1 hour.

Composite production

The composition of reinforcement materials ($CaCO_3$, snail shell filler and groundnut shell filler), and the matrix to filler ratio are presented in (Table 1). The right volume of the resin and filler were poured into a plastic container and stirred thoroughly for 20 minutes. Then the hardener was added to the mixture inside the container, and stirred for another 10 minutes. This mixture was poured into already oiled mould, filled to 25% of its depth. Then the glass fibre was uniformly spread on top of the composite mixture inside the mould, before the mould was filled with the mixture and covered with a ply board. The composite samples were removed from the moulds after 24 hours, cured at room temperature for a period of one week, before they were cut to size, in accordance to ASTM International standards.

Tensile testing

The tensile properties of the composite samples were tested in accordance to ASTM D368 procedure. The universal tensile machine (UTM) operating at a speed of 5mm/min was used to measure the tensile properties of each composite sample. At the end of each test, the tensile strength and tensile elongation of each composite sample were calculated with the expressions presented in Equations 1 and 2 (Uguru and Oghenerukevwe, 2021).

$$Tensile\ strength, \sigma = \frac{Force_{Max}}{Area} \quad 1$$

$$Elongation\ at\ Break, EB(\%) = \frac{\Delta L}{L} \quad 2$$

Where:
ΔL=extension at break point
L=original length of the sample.
F_{max}=maximum load applied to the sample.

Statistical analysis

Data gotten from the laboratory tests were statistical analyzed by using the Microsoft excel software.

RESULTS AND DISCUSSION

Tensile strength

The results of the tensile strength of the composite samples are presented in (Figure 1).

Table 1: Designation and composition of composite materials

Designation	Composition
C1	60wt% epoxy + 38wt% glass fiber + 2wt% snail shell filler
C2	60wt% epoxy + 36wt% glass fiber + 4wt% snail shell filler
C3	60 wt% epoxy + 34 wt% glass fiber + 6 wt% snail shell filler
C4	60 wt% epoxy + 32 wt% glass fiber + 8 wt% snail shell filler
C5	60 wt% epoxy + 30 wt% glass fiber + 10 wt% snail shell filler

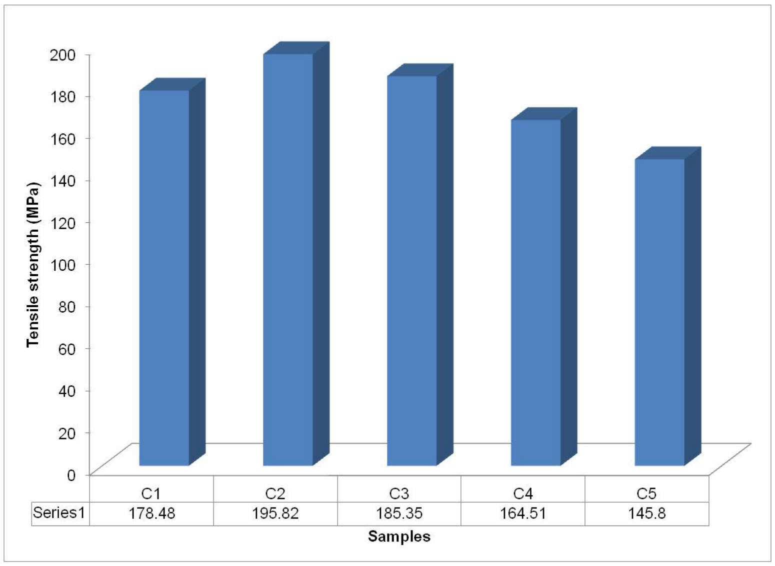

Figure 1: Tensile strengths of the composite samples.

As shown in (Figure 1), the volume of the snail shell filler influences the tensile strength of the composite samples. It was observed from the results that C2 composite sample had the maximum ultimate tensile strength (195.82MPa); while the C5 composite sample had the least ultimate tensile strength of 178.8MPa. As portrayed by the results, as the snail shell filler volume increased from 2 wt% to 4 wt%, the ultimate tensile strength increased from 178.48MPa to 195.82MPa. Then further increment in the filler volume, from 4wt% to 10 wt%, led to continuous decline in the tensile strength of the composite samples from 195.82MPa to 145.8MPa. This could be attributed to weak interaction between the filler and the matrix as the filler increases. This will lead to the formation of voids and weak interfacial adhesion in the process; hence negatively affecting the tensile strength of the composite produced (Turmanova *et al*., 2012; Akpokodje et al., 2021). Similarly results were obtained by Wicaksono *et al.* (2019) for calcium carbonate reinforced kenaffibre hybridized composite. According to Wicaksono *et al.* (2019), the tensile strength of the kenaf fibre hybridized composite increased progressively, as the $CaCO_3$ filler volume increased from 0 wt% to 5wt%, and then later decline as the filler volume increased from 5wt% to 7.5wt%. But in contrast, Sravani *et al.* (2017) reported that the tensile strength of $CaCO_3$ fillers reinforced glass fibre composite samples declined continuously from 181.8 MPa to 153.4 MPa, as the $CaCO_3$ filler volume increased from 5 wt% to 10 wt%. The differences between this study results and the previous results by Sravani *et al.* (2017), could be attributed to the type and volume of reinforcement used by the different authors.

Tensile elongation

The results of the tensile elongation of the composite samples presented in (Figure 2) portrayed that, the tensile elongation of the composite samples was dependent on the filler volume. As shown in (Figure 2) the tensile elongation of the composite samples increased from 11.9% to 13.5%, as the filler volume increased from 2 wt% to 4 wt%. The study further revealed that as the filler volume increased from 4 wt% to 10 wt%, the tensile elongation of the composite samples decreased from 13.5% to 8.1%. This signified that as the volume of the filler increased from 4 wt% to 10 wt%, the composite samples lost this ductility and become more brittle. These results further affirmed previous research (Araujo *et al*. 2006) results that, increment of glass fibre

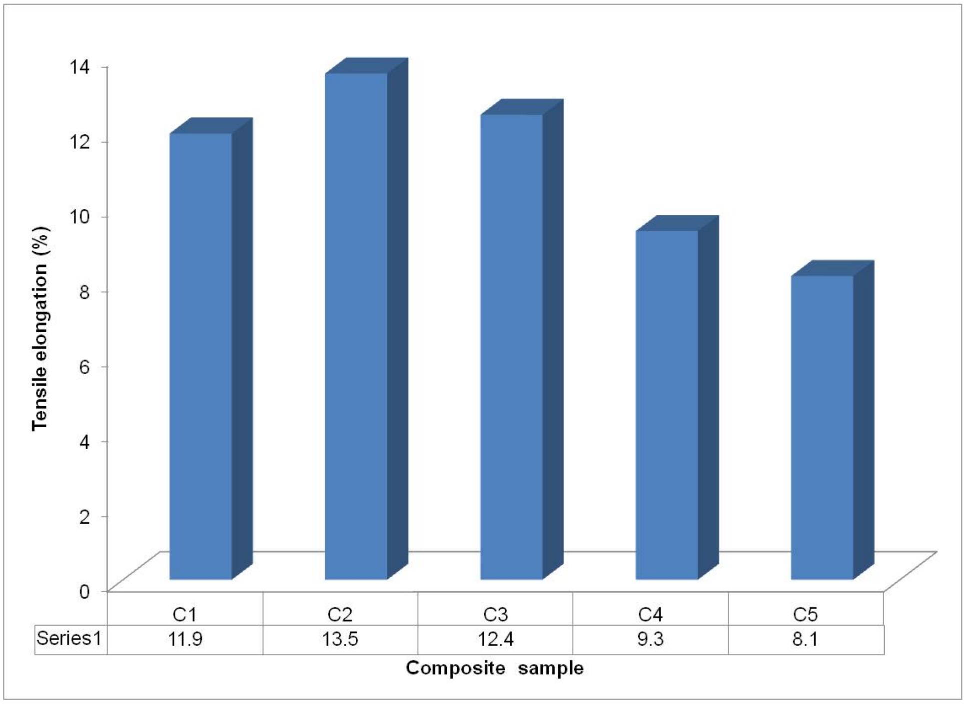

Figure 2: Tensile Elongation of the composite samples.

enhances the tensile elongation of composite samples. According to Araujo *et al* (2006) 40% glass fibre reinforcement gave the maximum tensile elongation of glass fibre reinforced polyester resin composite. As reported by Uguru and Oghenerukevwe (2021), the incorporation of snail shells filler at lower volume (less than 8 wt %) improved the tensile properties of the epoxy composite materials. Results obtained from this study signified the potential of using treated snail shell filler, as reinforcement material in the production of composite materials for various industrial applications. This will enhance the production of green composite; hence minimizing environmental hazards caused by synthetic fibres.

Conclusion

The influence of snail shell filler on the tensile properties of glass fibre reinforced epoxy matrix composite samples was evaluated in this study. Composite samples were produced by partial replacement of glass fibre with snail shell filler, and their tensile characteristics tested in accordance to ASTM International standards. Results obtained from this study revealed that the tensile properties of the composite samples were dependent on the filler and glass fibre volume. The hybridized epoxy composite reinforced with 36 wt% glass fiber and 4 wt% snail shell filler, had the maximum tensile strength and tensile elongation; while hybridized epoxy composite reinforced with 30 wt% glass fiber and 10 wt% snail shell filler, had the lowest tensile strength and tensile elongation. As revealed by this study results, low volume of snail shell filler can be used as partial replacement for fibre glass. This will enhance the production of green composite; hence minimizing environmental hazards caused by synthetic fibres.

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