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The properties of coconut coir fiber reinforced epoxy composites

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KEYWORDS

Coconut coir, epoxy composites

ABSTRACT

Natural fibers are not only strong and lightweight but also relatively very cheap, low in density, recyclable and biodegradable. Low density values allow composites production that combine good mechanical properties with low specific mass. In Malaysia, fibrous plants are available in abundance such as coconut coir. In this research, an investigation has been carried out to study the properties of coconut coir fiber reinforced epoxy composites. Samples were prepared at different filler loading, 0%, 5% and 15%. Investigation were carried out using water absorption and tensile test. From the results, it was found that drastic increment of water absorption occurred for the first 5 days for all samples. EPO15 showed the highest increment followed by EPO5 and EPO0 at 5.87 %, 2.86 % and 1.71 % respectively. The young modulus for the prepared samples were 30.95 MPa, 1706.22 MPa and 73.55 MPa for EPO0, EPO5 and EPO15 respectively. This showed that that coconut coir/epoxy composites exhibit moderate to low physical and mechanical properties at low fiber loading.

1.0 INTRODUCTION

Natural fiber reinforced polymer composites play important roles in the production of eco-friendly materials because of their high modulus, strength and reduced carbon footprint on the environment. Coconut (cocos nucifera) is cultivated extensively in tropical countries for its fruits whereas the husks and shells are mostly disposed as waste. These portions of the coconut plant serve as potential resource for natural fibers which are used to reinforce polymer composites. Researchers are triggered by daily growth of environmental awareness and this leads to the invention of more eco-friendly materials (Adewale et al.,2019). Natural fibers from coir, oil palm, sisal, bamboo, banana, rice husk, jute, kenaf etc. are environmentally friendly materials that have proved to be good reinforcement in polymeric matrices reducing the density and cost of the resultant composites. However, in recent years, natural fibers have evolved as alternative to conventional glass and carbon fibers in the production of thermoplastic composites

Natural Fiber Reinforced Polymer-Composites (NFCs) have high corrosion and impact resistance, high stress to weight ratio, low maintenance requirements and are non-conductive. The design objectives of composites often include high strength on a weight basis often expressed in terms of specific strength and specific modulus. NFCs are produced with low density fiber and matrix materials have been found to possess exceptional high specific moduli and strengths

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(Anand et al., 2021). Natural fibers possess some inherent properties that may serve as drawbacks in their reinforcement of polymer composites, they include low resistance to microbial attacks, poor moisture resistance, poor adhesion between fiber-matrix surface and a tendency to form aggregates during processing. These drawbacks can be overcome by modification of the fiber surface which can be achieved by chemical treatment methods such as mercerisation, dewaxing, acetylation, chemical grafting, bleaching, delignification and salinisation and also physical treatment methods such as corona discharge, ionisation radiation and plasma. NFCs are important because of the substantial improvement of their mechanical properties which could make it possible for them to be useful in practical applications. The properties of composites depend on various factors such as fiber-matrix adhesion, fiber length, fiber content (loading), fiber treatment, fiber dispersion in the matrix. Tensile, Flexural and Impact strength are the mechanical properties mainly analysed by researchers for a wide range of composites. Natural fibers have applications in the automobile, construction, aircraft, medical and electronic industries as alternatives to concrete, timber, glass fiber, steel and so on (Arya et al., 2020). The use of NFCs has increased tremendously because of their high tensile strength, corrosion resistance, high stiffness, light weight, environmental friendliness etc.

Coconut coir is a hard and stiff biodegradable lignocellulosic fiber that are obtained from the fibrous mesocarp of coconut fruits and makes up about 25% of the nut. Coconut is cultivated extensively in tropical countries such as Thailand, India, Lanka etc. Due to the high lignin content of coir fibres, they are durable, weather resistant and relatively waterproof and be chemically modified. The fibers also have high elongation at break i.e. they can also be stretched beyond the elastic limit without rupture. In order to improve the overall properties of the composites, studies have reported the hybridisation of coir fiber composites with other fibers such as kenaf, bamboo, rice straws and glass fibers among others. Many authors have given overview on the production process and mechanical properties of various fiber composites such as but less effort have been focused on coir fiber composites alone. This work provides an investigation on coconut coir fiber (ccf) incorporated in epoxy composites.

2.0 EXPERIMENT PROCEDURE

The basic materials used was coconut coir. The fiber was collected and washed to remove any impurities, followed by drying process in oven for overnight. The matrix used was epoxy (DGEBA) and hardener both from Morcrete BJC 39. The gel time obtained was 40 minutes.

The coconut fiber was crushed into powder using grinder machine. Then the fiber was mixed with epoxy resin and hardener. Cautioned need to be practice to avoid bubbles formation. During mixing process, exothermic reaction occurred. The percentage of filler loading used in this study were 0%, 5% and 15% and samples were labeled as EPO0, EPO5 and EPO15 respectively. To produce coconut coir fiber reinforced epoxy composites board, aluminium mould was used. The mixture was poured into the mould and cured in oven for 24 hours at 30°C. Then the composites board was obtained and were cut into specimens for further testing.

Water absorption test was conducted according to ASTM D570. Prior to the immersion, all samples were conditioned in an oven at 50°C for 24hours. The samples were immersed in water at room temperature for up to 43 days. The samples were dried and weighted. Tensile test was prepared as referred to ASTM D638. Minimum of five samples were tested and the results were averaged.

3.0 RESULTS AND DISCUSSION

In the water absorption test, the absorption of water by the substance were measured. The amount of water absorbed affect polymers in different ways such as its physical, dimensions and properties. The water absorption of ccf/epoxy composites was conducted for 43 days at room temperature. The water absorbed into the samples via every side of the samples as shown in Figure 1.

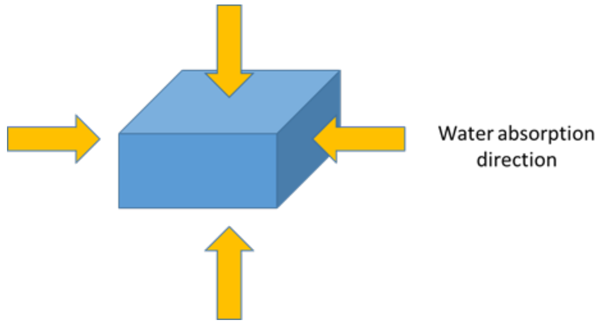

Figure 1: Absorption of water into the ccf/epoxy composites samples.

The test was performed until the material reached saturated state and the results are shown in Figure 2. From the graph, small increment for EPO0 and EPO5 was shown, while EPO15 showed higher increment of water absorption. The drastic increment occurred for the initial 5 days for all samples. After day 5, the water uptakes were increased slowly because saturated state were achieved.

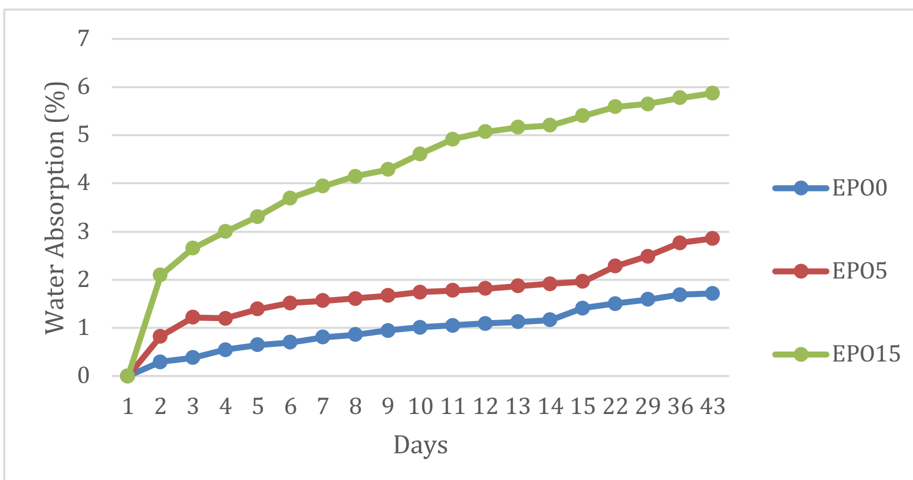

Figure 2: Water absorption of ccf/epoxy composites.

The limiting factor for large scale production of natural fiber composites is water absorption. Natural fibers absorb water from air and direct contact from the environment. This absorption deforms the surface of the composites by swelling and creating voids. Thus deteriorate its properties and increase the mass.

The increase in filler loading in ccf/epoxy composites displayed an increments in the water absorption percentage. The percentage increase slowly for EPO0 and EPO5 compared to EPO15. In the lower filler content of the composites, the material had denser space compared to the composites at higher filler content. Water molecules filled up the holes in the composites until they were saturated. Consequently, the higher the filler content, the lower its density, the higher the voids in the composites. Thus the higher the water absorption effect on the material.

The results of the tensile strength, strain and modulus of ccf/epoxy composites under different loading are shown in Figure 3, 4, and 5 respectively. From the Figure 3, EPO5 showed the highest value of tensile strength followed by EPO15 and EPO0. It can be seen that increase in loading of ccf resulted in the increase of tensile strength of the composites. The presence of more than 5% ccf in ccf/epoxy composites changed the properties noticeably.

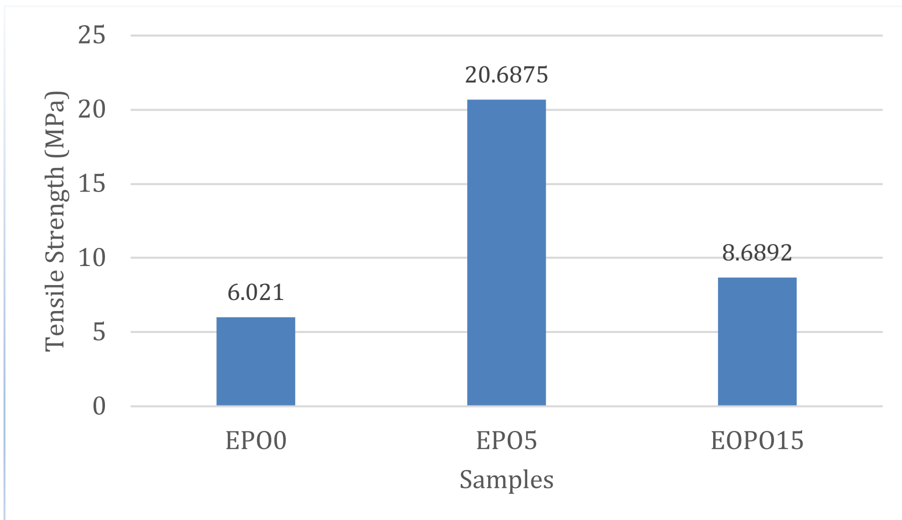

Figure 3: Tensile strengths of ccf/epoxy composites

Figure 4 illustrated the tensile strain at break of the ccf/epoxy composites. The contradiction trend can be noticed for the strain results and the tensile strength of the composites. During the test, all composites showed brittle fractures without any appreciable yielding. Thus small values of strain were expected.

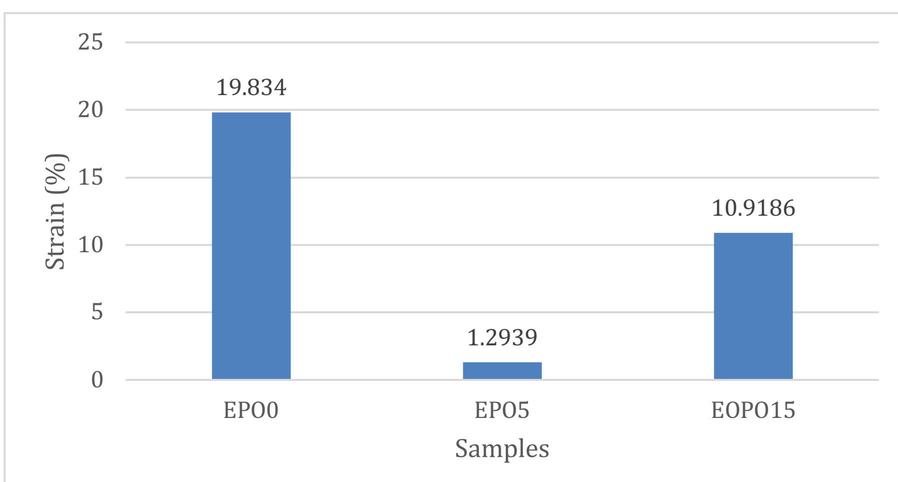

Figure 4: The effect of ccf loading on tensile strain at break of ccf/epoxy composites.

Modulus is a measure of the resistance to elastic deformation. An increase in the modulus shows that the material exhibits a high resistance to deform elastically. Young's Modulus of ccf/epoxy composites is shown in Figure 5. The increase in Young's modulus of EPO5 was perhaps contributed by the epoxy matrix which gave elastic properties to the composites. But in EPO15, the amount of matrix was less with most of the composites filled with ccf. Thus the matrix was no longer able to sustain elastic deformation which resulted in the reduction of Young's modulus in EPO15.

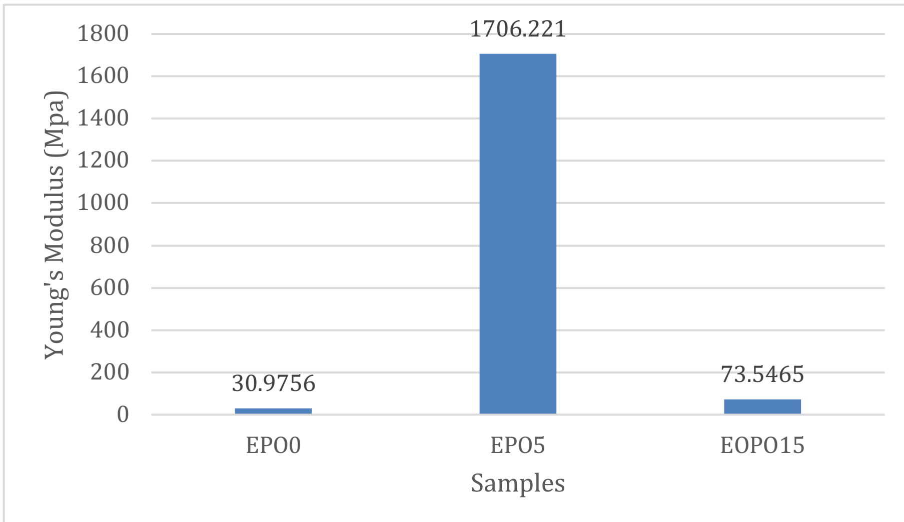

Figure 5: The effect of ccf loading on Young's modulus of ccf/epoxy composites.

4.0 CONCLUSION

Based on the research conducted and the results obtained, the following conclusion are drawn:

- The water absorption percentage increase upon an increase in the fiber content of ccf/epoxy composites.
- An increase in the percentage of ccf/epoxy composites results in increasing in its tensile strength from 6.01 to 20.69 MPa, but at 15% loading cause the tensile strength to decrease to 8.68 MPa.
- It is suggested that the filler loading of 5% ccf is the optimum filler content since a higher loading would decrease the physical and mechanical properties.
- Fabrication of ccf/epoxy composites were simple and did not involve extreme condition hence suitable for further investigate to shed more light on the properties of the composites.

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