Synthesis and Mechanical Properties of Kenaf/E-glass fiber Hybrid Composite

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ABSTRACT

The use of natural fibers in composite is increasing in recent years due to their lightweight, non-abrasive, combustible, non-toxic, low cost and biodegradable properties. However, in comparison with synthetic fibers, the mechanical properties of natural fibers are lower. Therefore, the inclusion of synthetic fibers could improve the performance of natural fiber based composites. The demand for hybrid composites (natural + synthetic fiber) is increasing due to recent advances in construction, automobile, household, military structures and other industries.

In this work, hybrid composite is prepared by using untreated Kenaf fiber and E-glass fiber reinforcement with Bisphenol unsaturated polyester resin polymer matrix. Kenaf/fiberglass hybrid composites were fabricated by a combination of hand lay-up and cold-press compression molding methods. The prepared composites were tested for tensile, flexural and impact strength (Izod test) as per ASTM D7264, ASTM D638 and ASTM D256 standards respectively. Also harness (Brinell) and water absorption test were carried out. Results of the tests are tensile strength, flexural strength, impact energy and hardness are 87.5 MPa, 3.94 MPa, 15.75 kJ/m^2 and 24.45 kgf/mm^2 respectively. Water absorption tests were conducted in two environmental conditions including sea water and distilled water. Results indicated that the mechanical properties of kenaf fiber are decreased after the moisture penetrates into the composite.

KEY WORDS: Kenaf fiber-E glass fiber + Bisphenol polyester resin polymer composite, tensile strength, flexural strength, impact strength, water absorption property.

1. INTRODUCTION

Polymer matrix composite (PMC) is a composite material consisting of polymer (resin-Bisphenol unsaturated polyester) combined with fibers (glass-kenaf hybrid) reinforcement in the form of laminates. The natural fiber that was used in this study is Kenaf fiber. It requires less water to grow. Natural fibres are an alternative reinforcement in polymer matrix composites have attracted the attention of researchers due to their advantages over conventional glass and carbon fibers (Salleh, 2012). The use of natural fibers in PMC is increasing in recent years due to their lightweight, non-abrasive, combustible, non-toxic, renewable and biodegradable properties (Chern Chiet Eng, 2014). However, in comparison with synthetic fibers, the mechanical properties of natural fibers are lower as well as poor moisture resistance especially absorption and low strength compared to synthetic fiber such as glass (Ghani, 2012). Therefore, the inclusion of synthetic fibers (E-Glass) could improve the mechanical performance of natural fiber based composites. Common everyday application of PMCs are includes: Aircraft, Boats and marine, Sporting equipment (Golf shafts, tennis rackets, surfboards, hockey sticks), Automotive components, Wind turbine blades, Body armour, Building materials, Water pipes, Bridges, Tool handles, Sound proof applications, etc.

From the literature, it was found that little work is carried in mechanical characterization of kenaf-glass (KG) hybrid fiber composite with Bisphenol resin. Therefore, the aim of this paper is to synthesis KG reinforced polyester hybrid composite to reduce the cost of production and the harmful destruction in normal environment.

2. MATERIALS AND METHOD OF FABRICATION

The E-Glass fiber (synthetic fiber) was used in this work which is woven in the form of mat. Both fibers were used as received without any chemical or thermal treatment. The detailed procedures used for synthesizing PMC are given below.

Material selection:

- Resin - Bisphenol unsaturated polyester
- Fibers - Kenaf, E-glass fibers
- Accelerator - Cobalt Naphthalate
- Promoter - Benzyl Peroxide
- Catalyst - Methyl Ethyl Ketone Peroxide

Preparations of composites:

- A combination of hand lay-up and cold press method was used in the fabrication of the composite laminates.
- The matrix material was prepared from the unsaturated polyester resin and the accelerator at the weight ratio of 100 to 2 and stirred.
- The promoter and catalyst was added to the polyester one after another and the batch was stirred before pour into a mold.

- Three kenaf fibers were arranged inside the mold and layered by fiber glass in a sandwich pattern. Two mats of fiberglass with nominal size 300 mm x 300 mm used in each layer. The fiber glass was put in upper and lower part of a composite laminate.
- Then, the polyester matrix was poured onto the Kenaf fiber and fiber glass in a mold. Fig.1 shows the initial steps used in PMC process.
- The size of the mold was the 300 mm x 300 mm. Plastic firm was swept by the wax and the mold was covered with the steel frame for easy removal and good finishing of the laminate specimen.

a

b

Figure.1. PMC fabrication: a) Hand lay, b) Compression moulding method

Cold pressing with 10 kN load was applied to the laminate specimen for 15 to 20 minutes at room temperature to ensure the specimen has no air bubble and ensuring the homogeneity.

Finally, the laminate was removed from the mold and cured for 24 hours at room temperature to ensure the laminate is hard and dry enough for the cutting process.

Final laminate was fabricated with thickness of 4 mm which consisting of 3 kenaf and 2 E-glass layers (60% kenaf+40% E-glass). Figure.2, shows the fabricated composite laminate.

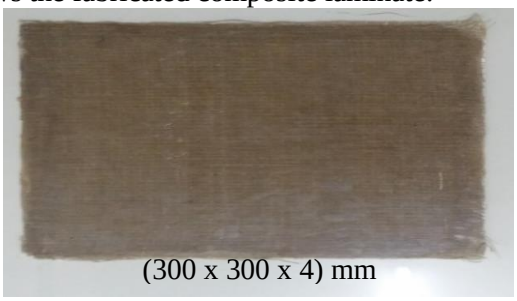


Figure.2. Fabricated laminate

3. MECHANICAL CHARACTERIZATION AND RESULTS

In order to assess the quality of the prepared PMC, the following mechanical destructive tests have been carried out. All the tests were conducted for three samples and average of three samples was taken as a final result.

Tensile test:

- Tensile test is done on Universal testing machine with a standard of ASTM D638.
- The tensile strength is found out to be 87.5 MPa by measuring max load of 2.1 kN.

Tensile strength=Max load/original cross sectional area =87.5 MPa

Where, CS area =6x4 mm^2. The obtained tensile strength is more than the work carried by Sharba in 2015 in which the tensile strength is 48 MPa for Kenaf+E-glass+ unsaturated polyester hybrid composite.

Flexural strength test:

- The test is carried out by Universal testing machine TUE CN-60 under ASTM D7264 by 3 point flexure test.
- The size of the sample is 127 mm x 12.7mm x 4mm
- Max load is 0.2 kN

Flexural strength=Max load/original cross sectional area =3.94 MPa

Impact strength test: Izod impact test specimens were prepared as per ASTM D256 standard.

- The sample size is 63.5 x 12.7 x 3mm, while the notch length is 2.54mm.
- The impact energy required to break the sample is 2 Joules

Impact strength=2 /12.7 x10 =15.75 kJ/m^2

In order to reduce the brittle fracture, in this work, kenaf fiber is used more (60%) than E-glass fiber (Abdul Malek Ya'acob, 2011).

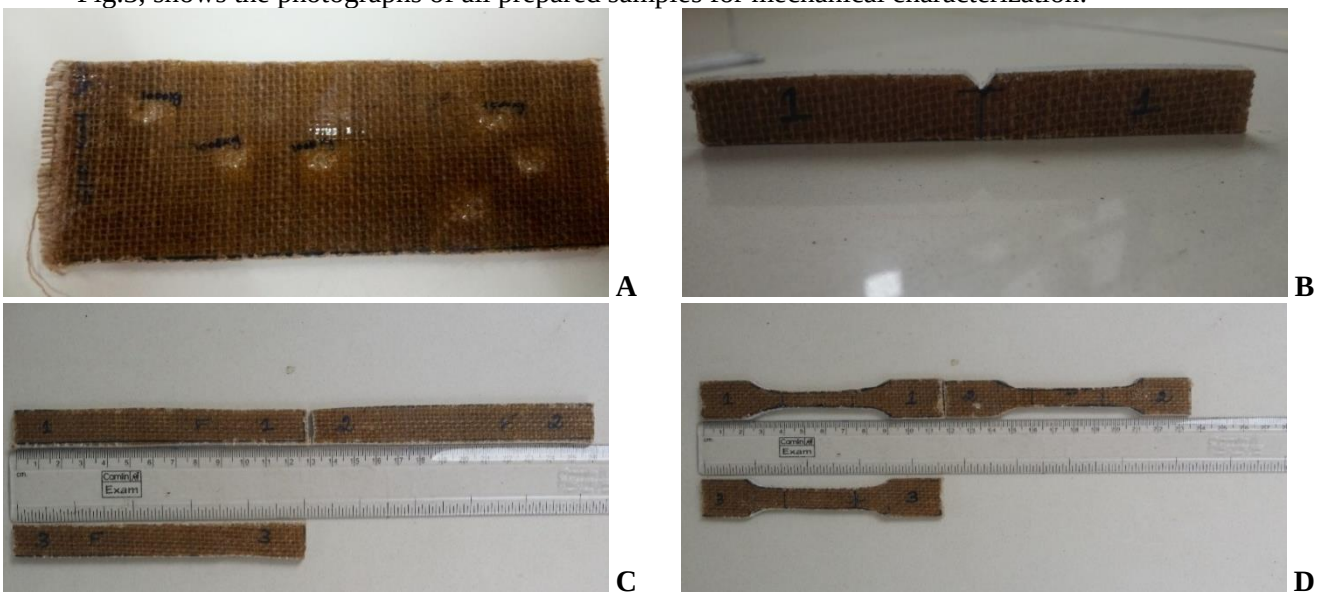
Hardness test: Hardness test is done by Brinell Hardness tester in Brinell Hardness testing machine of TKB-3000.

- Diameter of the steel ball indenter (D) =10 mm
- Diameter of the indentation (d) =6.85 mm
- Load required to make indentation (P) =1000 kg

$$BHN = \frac{2P}{\pi D(D-\sqrt{D^2-d^2})}$$

Brinell hardness is found out to be 24.45 BHN.

Fig.3, shows the photographs of all prepared samples for mechanical characterization.



A **B** **C** **D**

Figure.3. Samples prepared for Mechanical characterization [A] Hardness Test, [B] Impact Test, [C] Flexural Test, [D] Tensile Test

Water absorption test: Normally PMCs are used in boats which are running in normal and sea water. Therefore, water absorption test method provides a means for measuring absorption as a result of direct contact exposure to water. Water absorption tests were conducted by immersing specimens into salt water and distilled water at room temperature for five days. Results show that the mechanical properties of hybrid composite were decreased after the moisture absorption into the composite which is due to dissolving of resign in the water.

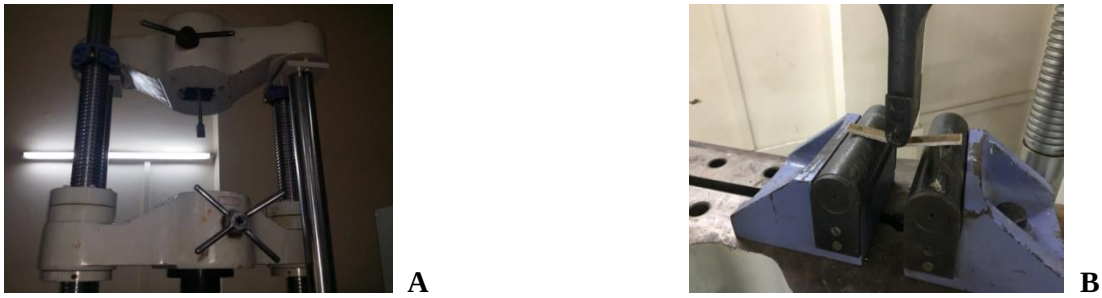
The moisture uptake expressed in percent weight gain, ΔM, is

$$\Delta M = \frac{Mt-Mo}{Mo} \times 100\%$$

M_t is mass of sample after immersion, M_o is mass of sample before immersion.

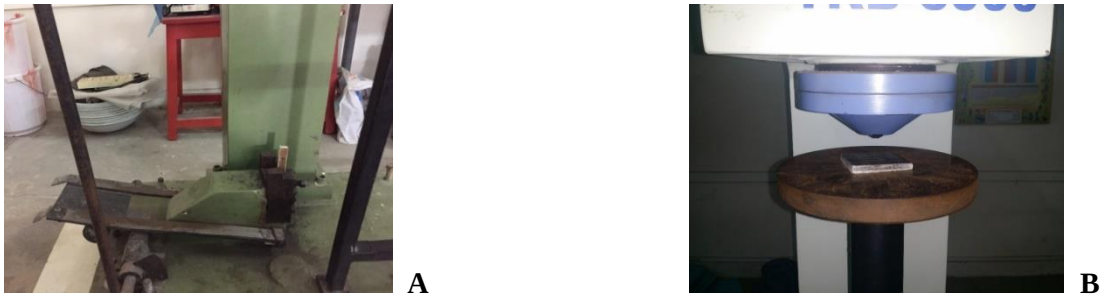
- Moisture uptake percentage in distilled water is 13.49%
- Moisture uptake percentage in salt water is 16.38%

Figs.4 and 5 shows the photographs of all mechanical property test condition and table.1 list the results obtained from different tests.



A **B**

Figure.4. Property testing condition [A] Tensile Test, [B] Flexural Test



A **B**

Figure.5. Property testing condition [A] Impact Test, [B] Hardness Test

Table.1. Results - Mechanical properties of synthesized composite

Mechanical properties		Values
Tensile strength (MPa)		87.5
Flexural strength (MPa)		3.94
Impact strength (kJ/m^2)		15.75
Hardness (BHN)		24.45
Water absorption coefficient (%)	Distilled water	13.49
	Salt Water	16.38

4. CONCLUSIONS

- The results obtained from PMC of present work were better in terms of its tensile strength and hardness as a comparison between kenaf, E-glass fiber and kenaf/E-glass hybrid composites.
- Results showed that the addition of E glass fiber resulted in brittle failure and a higher amount of kenaf fiber with low % of E-glass fiber causing low strength, high ductile and toughness behavior.
- Water absorption tests were conducted and results showed that moisture intake percentage is more in salt water compared with distilled water.

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