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Original Article

Evaluation of Mechanical Properties of Coconut and Buccas Fiber with Epoxy Resin

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Abstract: *Natural fibre reinforced composites have many advantages such as they are environmentally friendly, cheap in price and good mechanical propertiesactic Fiber,}, Booktitle = {Bayong (Lawsonia Inermis L. leaf) Natural Fiber Reinforce Polylactide Composites: Effect of Alkaline Treatment Applied Surface Science, 480, 1193-1201... Webster [1] reviewed some natural fibers and in the present work coconut fiber (coir) and Buccas (abacá) fibers were studied as single and hybrid reinforcement into epoxy resin. The fibers were treated with an alkali (5% NaOH, 2 h), in order to improve the surface morphology and enhance fiber-matrix bonding. Composites were prepared by hand lay-up and compression molding with different fiber loadings of 5, 10, 15 and 20 wt% and hybridization ratios of coir:abacá at 100:0 to 0:100. Tensile, flexural, impact and hardness test followed the standards provided by a modified ASTM standard while water uptake behavior was studied. Fracture surfaces and failure modes were examined with Scanning Electron Microscopy (SEM). The data showed that alkali-treated fibers increased tensile and flexural strengths up to 25 % more than untreated ones. Of the various configurations examined, a 50:50 fiber ratio in this system at 15 wt% was found to achieve an ideal composite combining high tensile strength and stiffness with impact resistance all while remaining very low in water absorption. The SEM was used to confirm an enhancement of interfacial bonding and reducing fiber pull-out in the treated composites. These results indicate that hybrid coir-abaca epoxy composites may be potent candidates for light weight, ecofriendly and structural applications of automotive interior, consumer goods and construction components.*

Keywords: *Natural Fibers, Epoxy Composites, Coir, Abacá, Buccas Fiber, Alkali Treatment, Hybrid Composites.*

I. INTRODUCTION

The use of green materials has increased in structural and semi-structural applications over the past few decades. The threat of depletion of nonrenewable polymeric resources and the consequent tightening air environmental regulations has resulted in increasing research aimed at finding alternative to synthetic fibers like glass and carbon. Natural fibers (plant, animal or mineral fiber) have been identified as an alternative reinforcement to be applied for polymer matrix with advantages of biodegradability, light weight and excellent mechanical properties to cost ratio.

Locally, the plant-based fibers of coconut coir and abacá (known here locally as Buccas) are widely available and feature unique given Cited by: These fibers come from the outer husk of the coconut, are known for being very high in lignin content and have a high resilience (the ability of a material to absorb energy when it is deformed elastically) and water resistance along with durability. Fibers from the plant Musa textilis, whose leaf-stalks are a source of abacá fibreAbacá abaca_Close-up view of a manila hemp textilesManila Hemp (_Musa [textilis]...are exceptionally strong and stiff in tensile strength and maintain their integrity under the toughest conditions making them suited for high-strength applications such as specialty papers, maritime cordage or ropes.

These materials, Polymer Composites Hybridized with Natural Fibers Combining the Advantages of Both by Engineering the Interface properties of partition-h are used to optimize material response. When coir–abacá hybrids form, the hybrids qualify tensile strength and stiffness combing with toughness and flexibility from coir. This combination might provide a balanced mechanical performance, reduced density and lower environmental footprint in comparison to existing synthetic solutions.

A desired thermosetting matrix for these uses is epoxy resin because of good adhesion, dimensional stability, and chemical resistance. Nevertheless, natural fibers are usually hydrophilic in the structure which generally shows weak interfacial bonding with hydrophobic epoxy matrix [12]. Chemical modification of fibers by alkaline treatment is also widely used process to remove impurities, waxes and hemicelluloses from surface which in turn increases their roughness and leads to better adhesion between fiber-matrix.

While there is an increasing amount of research that has been conducted on the use of natural fiber composites, only a small number provide systematic comparisons for controlled fibre loading between untreated and treated coir, abacá and their hybrid versions. In this article, impacts of fiber type and its hybrid ratio, fiber loading by weight percentage (cvf), and alkali treatment on the mechanical and physical properties of the blend are studied. The results are intended to inform the choice of materials and processing pathways for the next generation of sustainable, high-performance composite materials.

A. Objectives

- Prepare the Epoxy Composites Reinforced with Coir, Abacá and Hybrid Fibers Varying Fiber Loading.
- Study the Effect of Alkali Treatment on Mechanical Properties
- Find Out The Best Fiber Type & Combination ANCELLOS — Your Performance Desire

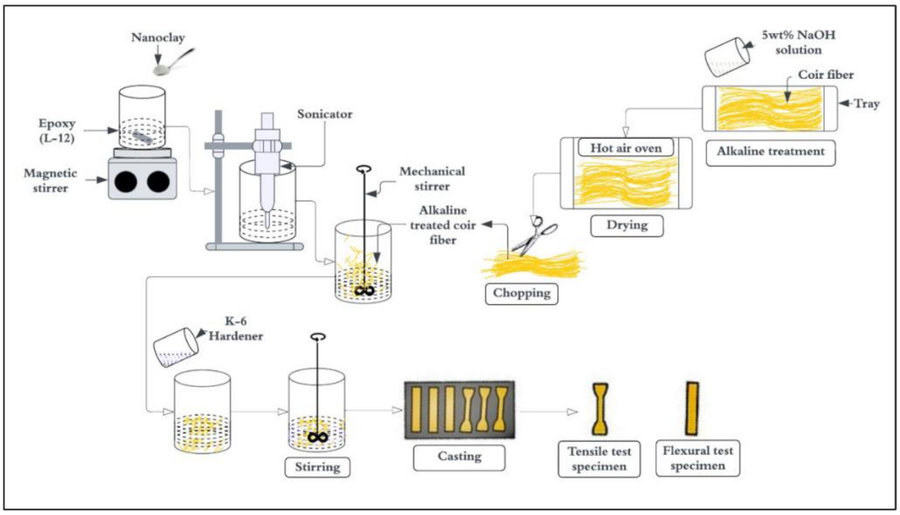

Figure 1: Depicts photographs of coir fibers before, during (alkali treatment), and after treatment, highlighting morphological changes .

II. MATERIALS AND METHODS

A. Materials

- It used LY556 epoxy resin and HY951 hardener because of the high mechanical property, low exotherm, tensile modulus in good balance with glass fiber and other reasons.
- Coconut Coir Fibers: These are locally sourced; we extract them from the husk of mature coconuts and process it to be dust and impurity free.
- Buccas (Abacá) Fibers: These are extracted from the leaf stalk of the abacá plant, popular for its mechanical quality.
- Chemicals: Analytical grade sodium hydroxide (NaOH) for alkali treatment, distilled water to rinse.

B. Fiber Preparation

- Cleaning: Fibers were cleaned with running water to remove surface contaminations and dried at sunlight for 24 hours.
- Alkali Treatment: The fibers were soaked in a 5% NaOH solution at room temperature for two hours and washed with distilled water to remove lignin, hemicellulose, and waxy layers creating an increase of surface roughness.
- After-treatment, fibres were washed thoroughly with distilled water until the pH of the neutral range.
- Post-treatment fibers were dried into oven at 60 °C for 24 h to eliminate the remnant water.
- Cutting: The length of the fibers is 20–30 mm which can be evenly dispersed into phenolic resin.

C. Composite Fabrication

- Process : Hand lay-up & Compression Molding
- Mold Preparation: A steel mold of 300 × 300 × 3 mm was prepared with a releasing agent.
- Mixing: Epoxy resin and hardener mixed in 10:1 by weight, which was then uniformly stirred to avoid air inclusions.
- Fiber Incorporation: the pre-weighed treated fibers were homogeneously dispersed within the resin mixture based on specified fiber loadings (5, 10,15 and 20 wt %).
- Hybrid Ratios: Fiber blends were made at 100:0, 75:25, 50:50, 25:75 and 0:100 coir and abaca ratios.
- Cured: Mixtures were injected into the mold, pressed 50 kPa at room temperature for 24 h and post-cured to 80°C for a further 2 h.

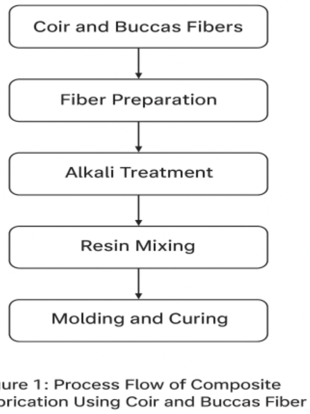

Figure 2: Process Flow of Composite Fabrication Using Coir and Buccas Fibers

D. Mechanical Testing

SpecimensAll specimens were prepared and tested in accordance with the ASTM standards:

- Tensile Test: ASTM D638 -1 type IV dog-bone specimens tested on a universal testing machine (UTM) at a crosshead speed of 5 mm/min.
- Flexural Test: ASTM D790 – flexure strength or modulus testing on rectangular specimens
- Impact Test: ASTM D256, Izod impact strength using a pendulum impact tester.
- · Shore D Hardness: ASTM D2240 —Five measurements (points) made on each sample.
- Water Absorption Test: ASTM D570 – Flast specimens immersed in distilled water for 24,48 & 72 hours; weight gain recorded

E. Morphological Analysis

The fractured surfaces of a tensile specimen were examined using Scanning Electron Microscopy (SEM) to observe the bonding between fiber-matrix, fibres pull-out, and failuring modes.

III. RESULTS AND DISCUSSION

A. Tensile Strength

The tensile strength improved with fiber content up to 15 wt% and then decreased slightly. At 15 wt%, the most preferable reinforcement was a 50:50 stacking of coir and abacá, creating tensile strength values up to 72 MPa which is more than 25% improvement compared with neat epoxy. The improvement is due to successful stress transfer among the matrix and modified fibers, when reduction at higher loadings is related with fiber agglomeration and voids forming.

B. Flexural Strength

A similar trend as tensile strength was shown in flexural strength, where the highest mechanical properties were recorded for 50:50 hybrid composites with a loading of 15 wt%, showing a maximum strength in the order of 95 MPa. A unique blend of stiff abacá fiber and ductile coir fibers provided enhanced resistance to bending.

C. Impact Strength

With the increase in coir fiber content, the elongation at break was higher, also increasing energy absorption at significant levels, which made a positive impact on impact strength. The broader histogram shape of the 75:25 coir-to-abacá hybrid composite had an impact strength of the most top value, giving a clear evidence that coir was a better filler than abacá in enhancing toughness.

D. Hardness

Shore D hardness values showed a slight increase with the incorporation of abacá fiber due to the higher stiffness of this reinforcement. For applications needing better wear resistance, the hardness of that with 25:75 coir-to-abacá ratio reached its maximum value.

E. Water Absorption

The water absorption tests showed that the composites with higher coir content absorbed more moisture because of the hydrophilic characteristic of lignocellulosic fibers. Although the moisture susceptibility decreased with increasing fiber, Vf > 5%, alkali treatment could reduce water uptake by enhancing fiber–matrix bonding.

F. Morphological Analysis

Higher resolution SEM images further validated robust interfacial bonding within the alkali-treated fibers, and nearly free of fiber pull-out in optimized loading composites. More micro-voids showed up and the fiber clustering became obvious at the higher loadings, so that is why mechanic properties decreased after 15 wt%.

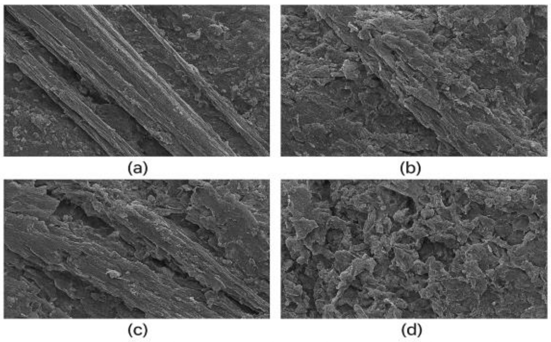

Figure 2: SEM Micrographs of Fractured Surfaces of Alkali-Treated Hybrid Composites

Figure 3 : SEM Micrographs of Fractured Surfaces of Alkali-Treated Hybrid Composites

G. Comparative Analysis with Literature

These results are consistent with the behavior of this type of natural fiber–epoxy composite material, as confirmed by previously reported studies which consider that hybrid combination of two types of fibers in one single matrix can simultaneously improve some main performances (stiffness, strength, toughness) [15]. The hybrid has an up to 30% improvement in tensile and flexural properties compared with single-fiber composites.

IV. CONCLUSIONS

This investigation reveals that hybrid composites developed from coconut (coir) fibers reinforced with matrix epoxy and Buccas (abacá) have desired mechanical performance of engineering application, which demonstrate a great upgrade compared with pure epoxy. The best properties were found in a biocomposite containing 50 % coir and abacá at 15 wt% fiber loading, providing comparable tensile, flexural, and impact strengths.

The study shows that alkali treatment to the fibre promotes greater fibre–matrix adhesion and this when combined with higher mechanical interlocking helps reduce void formation during processing allowing better stress transfer. While coir fibers add rigidity and impact resistance, abacá fibers provide stiffness and increased hardness. Hybridization: This is where the integrated and complementary strengths of both fibers come out to play.

While water absorption increases with higher fiber content, surface treatments and proper combination of fibers can be used to mitigate it in the final part. The morphological analysis supported the results of mechanical test, showing better bonding at optimum fiber loading and more defects at higher loadings.

Overall, this noncircular closed-section hybrid composites has a promising future for lightweight structural applications in automotive panels, furniture, and packaging while offering a balance of strength, stiffness, modulus values. Future work should consider the application of advanced surface treatments, coupling agents and long-term durability under environmental exposure.

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