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Tensile and Wear Behavior of Calotropis Gigentea Fruit Fiber Reinforced Polyester Composites

Dilli Babu G[a]*, Sivaji Babu K[b], and Nanda Kishore P[c]

[a,c]*Department of Mechanical Engg., V R Siddhartha Engg College, Vijayawada-520007, India*

[b]*Department of Mechanical Engg, P V P Siddhartha Inst. Tech., Vijayawada-520007, India*

Abstract

An experimental study has been carried out to investigate the tensile and wear characterization of polymer composites made by reinforcing Calotropis Gigentea fruit fiber as a new natural fiber into a polyester resin. The Calotropis Gigentea fibres extracted by manual processes have been used to fabricate the composites. The composites are fabricated up to a maximum volume fraction of fibre of 0.35. The tensile strength increased with increase in fiber content. Further, the wear behavior of the Calotropis Gigentea fruit fiber composite were studied with increase in fiber content.

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1. Introduction

The term Natural Fiber Reinforced composites is now being applied to a surprising range of materials derived wholly or in part from renewable resources. Keeping up with the developments in technology, it is necessary to stop developing materials, which are environmentally insecure. This concept of renewable materials has now become of key importance due to the need to protect our environment. Bio-fibres like coir, bamboo, jute, etc are now finding applications in a wide range of industries. The field of bio-mass based research has experienced an explosion of interest, mainly with regard to its comparable properties to synthetic fibers within polymer composites. The major

* Corresponding author. Tel.: 0919393271212; fax: +0-000-000-0000 .
E-mail address: gdillibabu@gmail.com

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area of increasing usage of these composites is the automotive industry, mainly in interior applications. [1]

Natural fibers like bamboo, coir, jute, hemp, sisal, and banana in their natural form as well as several waste cellulosic products such as wood flour, shell flour and pulp have been used as reinforcing agents of different polymer composites. Several researchers have reported the behaviour of natural fibers and their composites by incorporating the fiber in different matrices before and after chemical treatments. [2–6]

The mechanical properties of natural fiber reinforced polymer composites can, in fact, be further enhanced by chemically promoting a good adhesion between the matrix and the fiber. Other advantages of utilizing bio-based fibers are related to their cycle of production that is inexpensive and their ease of processing which demands minor requirements in equipment and safer handling and working conditions with respect to synthetic fibers. In any case, the most attractive feature coming from the employment of bio-fibers is the extremely positive environmental impact, due to the fact that bio-fibers are produced from a renewable resource and are biodegradable. Also, bio-based composites can be easily recycled and avoiding damping at the end of their life cycle. Therefore, natural fibers represent an interesting alternative as substitutes for traditional synthetic fibers like glass and carbon. [7]

Even though, a very large amount of research work has been published on various bio-based natural fibers and their composites, an attempt has been made in the present research to introduce a new bio-based natural fiber as one of the fruit fibers and its use as reinforcement in the manufacture of new composite material for the light weight structures.

Calotropis gigantea is a medium sized shrub or small tree that grows up to 4m high with a generally waxy appearance and copious milky sap. The stem is ash coloured, smooth, branching sometime almost from the base. The leaves are grey-green, opposite, alternating, waxy, thick and rounded-ovate. They measure 5–15cm x 4–10cm with a short pointed tip and a heart-shaped base partly clasping the stem; a stiff brush of hairs occur at the base of the midvein. The fruit is a grey-green bladdery pod, 8–12 cm long, rounded at the base but shortly pointed at the tip and containing numerous seeds. The seeds are brown, flattened, with a tuft of long white hair at one end.[8] Calotropis gigantea Linn (Asclepiadaceae) commonly known as “Arka” in Sanskrit and “Mudar” in English has been claimed in traditional literature to be valuable against a wide variety of diseases. [13]

The objective of this research work is to study the fiber extracted from Calotropis gigantea by natural method and the use of these fibers as reinforcement in polester matrix. Calotropis gigantea fruit fiber reinforced composites at various percentage volume of fiber were fabricated, tested and characterized to study their mechanical and wear characteristics.

Nomenclature

FRP	Fiber Reinforced Plastics
NFRP	Natural Fiber Reinforced Plastics
CGFFRP	Calotropis Gigantea Fruit Fiber Reinforced Plastic

2. Fabrication and Testing

2.1. Materials and Methods

Unsaturated polyester resin (ECMALON 4411) was purchased from ECMASS Resin Private Ltd., Hyderabad, India. The resin has a density of 1240 kg/m^3, young’s modulus of 610 M Pa, Tensile strength of 29.2 M Pa and elongation at break of 4.5%.

2.2. Extraction of fibers

The fibers were extracted from Calotropis gigantea fruits by natural method. Later, the fibers were stripped from the stalks by hand, dried in the sun. After drying, any extraneous matter that may still be adhering to them was removed. The extracted fibers were used for composite making. The Calotropis gigantea fruit fiber is shown in figure 1.

Fig. 1. Calotropis gigantea fruit fiber

2.3. Fabrication of Composites

The Polymer Composites were prepared, using polyester matrix to assess the reinforcing capacity of Calotropis gigantean fruit fibers. The amount of accelerator and catalyst added to resin at room temperature for curing was1.5% by volume fraction of resin each. Hand lay-up technique was adopted to fill the prepared mould cavity with an appropriate amount of polyster resin and Calotropis gigantea fruit fiber, starting and finishing with layers of resin. Fiber movement should be minimized to yield good quality, fiber reinforced composite specimens. Therefore at the time of curing, a compressive pressure of 0.05MPa was applied on the mould and the specimens were cured for 24 hours. The specimens were also post cured at 70° C for 2 hrs after removing from the mould. The specimens were prepared with five different percentage volume of Calotropis gigantea fruit fibers. The picnometric technique was applied for measuring the density of the composite specimens.

2.4. Tensile Testing

The tensile behaviour of the Calotropis Gigantea Fruit Fiber Reinforced Plastic (CGFFRP) composites were prepared as per the standard ASTM D 638 M. The composite specimens with 160 mm long, 12.5 mm wide and 3 mm thick were prepared. Four identical composite specimens were tested for each percentage volume fraction of fiber. The specimens were tested at a cross-head speed of 2 mm/min, using a Tensometer (METM 2000 ER-1).

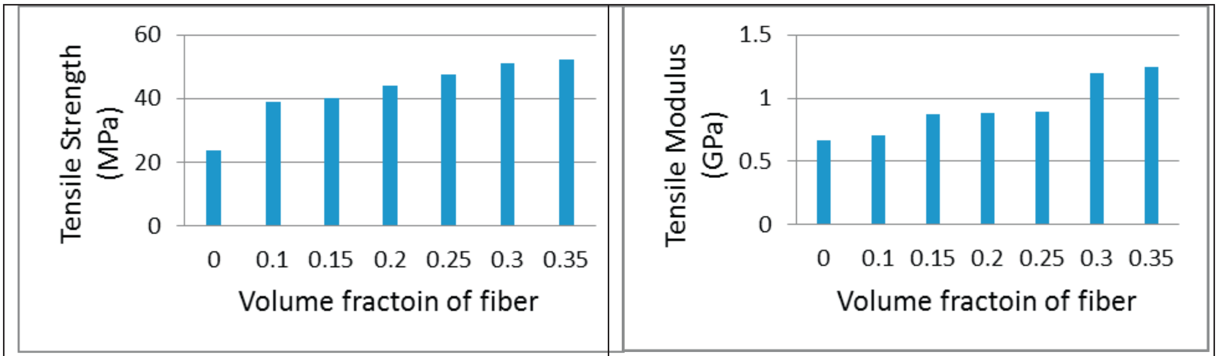
2.5. Wear Testing

The wear characteristic is measured using Tribometer (DUCOM; TL-20). The unit consists of a gimballed arm to which the pin is attached, a fixture which accommodates disks up to 150 mm in diameter & 10 mm thick, an electronic sensor for measuring the friction force. The motor driven turntable produces up to 0-2000 rpm. Wear is quantified by measuring the wear groove with a profilometer and measured the amount of material removed. Users simply specify the turntable speed, the load, and any other desired test parmeters such as friction limit and number of rotations. Since pins can be fabricated from a wide range of materials virtually any combination of metal, glass, plastic, composite, or ceramic substrates can be tested.

3. Result and Discussion

The variation of mean tensile strength and tensile modules with varying fiber content is presented in Figure 2. It was clearly evident that with increasing the fiber content in the polyester matrix, the tensile strength is also increasing. This is due to the fact that the polyester resin transmits and distributes the applied stress to the Calotropis gigantea fruit fiber resulting in higher strength. Therefore, the composite can sustain higher load before failure compared to the unreinforced polyester. The percentage increment in tensile strength of the composites over the pure polyester at the maximum fiber content (0.35 volume fraction of fiber) is found to be 52.26. This is understandable that the feasibility of developing new composites incorporating Calotropis gigantea fruit fiber which is abundantly available in nature, to be used in the field of consumer goods, low cost housing and civil engineering structures. The tensile modulus also increases as the volume fraction of fibre increases in the composites and is 1.25GPa at 0.35 volume fraction of the fiber loading (Figure 2).

The behaviour of wear with respect to weight loss and coefficient of friction is shown in Figure 3. It shows that the weight loss of composite increases with increase in fiber volume fraction and coefficient of friction decreases with increase in volume fraction of fiber. From the wear analysis, the 0.30 volume fraction Calotropis gigantea fruit fiber reinforced composites at pin load 3kg and sliding velocity of 50 cm/sec, the weight loss is 0.281 times more than of pure polyester.



(a) (b)

Fig. 2. Variation of (a) tensile strength (b) tensile modules of composite with volume fraction of fiber.

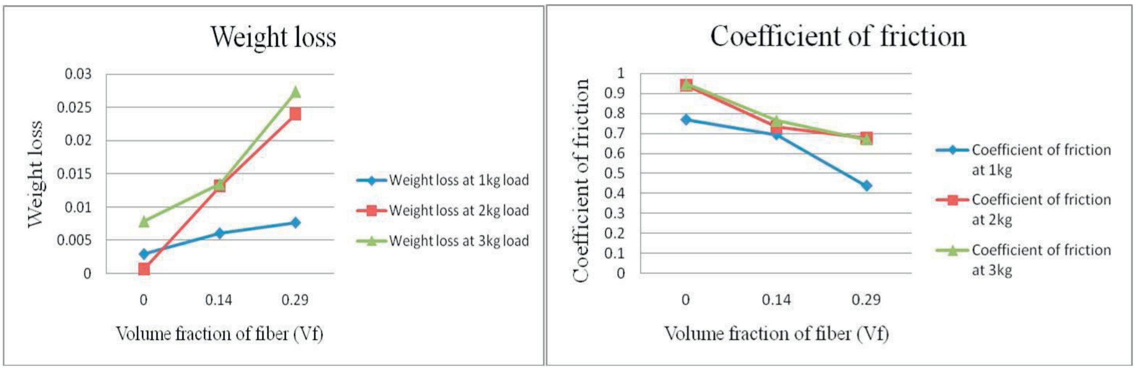


Fig. 3. Variation of (a) weight loss (b) coefficient of friction of composites with volume fraction of fiber.

4. Conclusion

In this work, Calotropis gigantea fruit fiber reinforced plastic composites were prepared. The Calotropis gigantea fruit is available abundantly in nature and has lower density. The tensile and wear characteristics of the composites with these fibers was found to be higher than those of the matrix and increased with fiber content. Thus the composites of Calotropis gigantea fruit fiber-polyester composites were found to be light in weight, possessed better mechanical and wear characteristics. This suggest that natural fiber reinforced plastic composites have a potential to replace synthetic fiber composites in many applications.

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