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STUDY OF MECHANICAL BEHAVIOUR OF EULALIOPSIS BINATA FIBER REINFORCED POLYMER COMPOSITE

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Abstract

In this investigation a new unexplored potential non-wood natural fiber, eulaliopsis binata (short fiber) is taken as reinforcement with epoxy as matrix material to examine the potential of the fiber as a reinforcement material. The incorporation of short eulaliopsis binata (sabai) fiber with different weight percentage (5,10,20,30,40) contributed towards enhancement of the mechanical properties of the composite. The modulus of elasticity, modulus of rupture, impact strength, hardness was found to be optimum for the composite with 30% weight fraction of fiber. The addition of fiber beyond 30% fiber fraction leads to fiber agglomeration, poor bonding at fiber matrix interface causing deterioration of mechanical strengths of the composite. The SEM analysis reveals fiber pullout, fiber-matrix debonding, micro crack propagation is found to be some of the primitive causes for the failure of composite under study.

Keywords: Natural fiber, Eulaiopsis binata, polymer composite, natural composite, mechanical properties, SEM; **1.**

Introduction

A significant portion of engineering materials starting from daily products like household appliances, doors and windows to sophisticated products like aircraft and space ships are made of composite materials [1]. The biggest advantage of composite materials from designer's point of view is the tailor made option for specific application and properties requirement [2]. There are various opportunities for the designers to choose among different matrix materials like polymer, metal and ceramic and also on the reinforcement side starting from synthetic to natural fiber to design and develop a new class of composite. Looking at the present day demand and environmental legislation, the interest of researchers is being shifted towards natural fiber polymer based composite [3]. Sisal, jute, bamboo, wheat and flax straw, banana has been proved to be good reinforcing material in the polymer matrices [4]. The decline trend in the wood raw material from forest created an urge in the research community to find out alternative sources of new raw material for growing composite industry. In this paper, a new class of fiber (non-wood material) has been utilized to find out its potential as a reinforcement in polymer matrices. These composites because of their low cost, higher strength and modulus and above all the biodegradable properties have been the subject of intense study in comparison to synthetic fiber composites.

Eulalipsis binata (sabai grass), a perennial plant known for its high fiber quality belongs to poacceae family of plant kingdom [5]. This plant is generally available in the eastern part of India along with some Asian countries such as china, Nepal, Pakistan, Myanmar, Thailand, Philippines, Malaysia. Eulalipsis binata fiber is used for making ropes, utility products and in textile industry [6]. These plants can be cultivated in degraded and up lands. The

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rainfall and manure is not necessary but availability of these can lead to better production of sabai pant. The sabai plant helps in conserving water in the soil which adds to the advantages such as low cost of the sabai grass fiber and good quality fiber. Their large-scale cultivation in barren hills and slopes have already been practiced and proved to have fast ecological benefits. The industry is associated with various activities of raising production of grass, processing of goods such as ropes, mats, carpets, sofa sets, wall hangings and other sophisticated, fashionable articles [7]. Being a renewable, sustainable fiber, this golden grass fiber possesses a tremendous potential in uplifting the economic status of the cultivators [8].

The average fiber length and ash content of sabai fiber is more than that of bamboo fiber which is being used as a fibre [9]. Based on morphological characteristics, the sabai grass is quite comparable and even better in some characteristics than that of bamboo fiber [10]. Microscopic examination reveals that sabai grass fibers are long, thin, slender and taper off to pointed ends. The unique morphological characteristics makes it desirable for good mechanical properties. In this present investigation, an attempt has been made to investigate the ability of the eulalipsis binata fiber as a reinforcement material in polymer composite.

2. Experimental Details

2.1. Materials

Fresh sabai grass stems were collected from mayurbhanj district of odisha state in india. The upper and lower portion along the length of the fiber were cut and removed because up to certain length at these portions they were having less diameter. After cutting these portions we get a long fiber of uniform diameter. Again the fibers were cut into a length of short fiber i.e. 11mm (optimum fiber length from fiber pull out test). Figure 1 shows the sabai graas stem to short fiber conversion. In this work Araldite LY556 was used as the epoxy resin with HY951 as the hardener with epoxy with a ratio of 10:1.

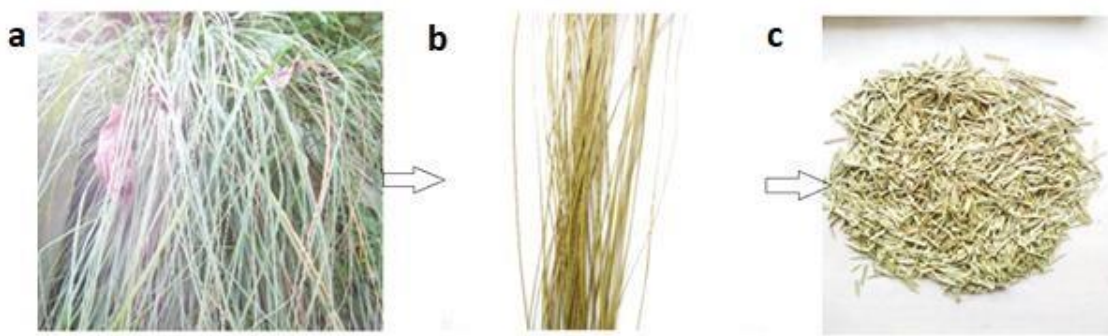

Fig. 1. (a) Eulaliopsis binata plant; (b) Processes long fibers; (c) Short fibers.

2.2. Composite fabrication for tensile and flexural test specimens

The composite samples were fabricated using a wooden mold by usual hand lay-up technique. At first, the weights of fiber and epoxy were calculated with the help of a weighing machine for different volume fraction of fiber. Then a mixture of calculated epoxy resin and hardener (ratio of 10:1 by weight) was formed by gentle stirring followed by mixing of the fiber. After proper mixing of powder and epoxy, the mixture was poured carefully into the mold. A mold release spray was applied throughout the inner surface of the mold before pouring so that the removal of composites was fast and easy. The mold was pressurized from the top by some weights and left for curing at room temperature for 24 hours. Care was taken to consider the loss of materials when they squeezed out of the mold due to application of pressure. This procedure was adopted for fabrication of composites which consists of 5,10, 20,30 and 40% weight fractions of fiber.

2.3. Tensile test

The samples were cut into the dog bone shape according ASTM D 3039-76 standard [11] and tested on an universal testing machine and tested on an universal testing machine. The test was conducted with span length 40mm and strain rate 2mm/min. Five samples were tested and average value of the results were considered. The modulus of elasticity of the specimens were found to be increasing order until 30% of the reinforced filler followed by the gradual decrease of tensile strength. *2.4. Flexural test*

Three-point bend test of the specimen was conducted using the same instrument as that of tensile strength test. All the specimens were of rectangular shape with dimension 140*20*5 mm^3.The test was conducted with a span length of 100mm and a cross-head speed of 0.5 mm/min [12].

2.5. Impact strength test

The impact test was conducted with izod impact tester and ASTM D 256 standard was followed [13]. The dimension 63.5*12.7*5 mm3 and a 'V' notch was made at the Centre of specimen with depth of 5 mm and 45° notch angle.

2.6. Micro hardness test

The micro hardness test was conducted on a LV 700 tester [14]. A diamond indenter with diagonals D1 and D2 was forced into the material under a load of F= 0. 3KgF.The following formula was used (1).

$$Hv = 0.1889F/D \quad (1)$$

where Hv= Micro hardness, D = (D1 + D2) / 2 and F = Applied load (in KgF).

3. Results and Discussion

The SEM images of the eulaliopsis binata fiber confirm the natural roughness of the fiber surface [Fig. 2(a)]. The fiber has a uniform structure throughout the length [Fig. 2(b)]. The circumference of the fiber is of wave like structure [Fig. 2(c)]. The void content tends to increase with higher percentage of fiber incorporation in composite [Fig. 3(a, b)]. The modulus of elasticity of the specimens were found to be increasing order till 30% of the reinforced fiber followed by the gradual decrease of MOE [Fig. 4(a)]. It was observed that the highest MOR found at a fiber percentage of 30% [Fig. 4(b)]. The decreasing amount of resin with respect to fiber may have caused nonuniformity in proper distribution of fiber in the resin and resulted to flexural strength losses. The impact strength increased as the fiber was added to the resin but as the reinforcement percentage crosses 30 weight percent of the composite the impact strength decreased gradually [Fig. 5(a)]. The deterioration of the strength may be due to the poor bonding between matrix and fiber after a certain percent [15]. The addition of fiber to the resin increased the hardness of the composite up to 30% fiber percent [Fig. 5(b)]. Due to the non-uniform distribution of resin with the fiber lead to the gradual decrease in the hardness of the composite slab [16].

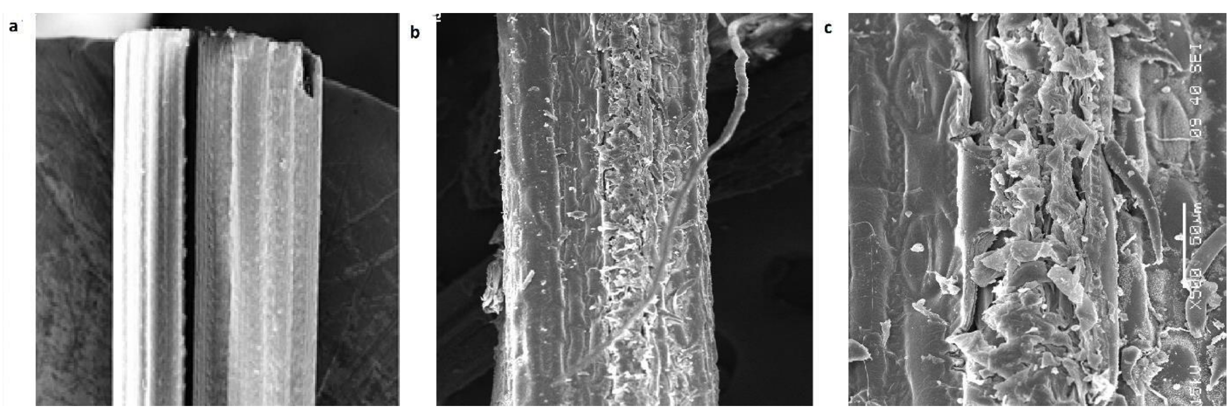

Fig. 2. (a) Long fiber cross section; (b) Magnified view of external surface; (c) Internal structure of the fiber.

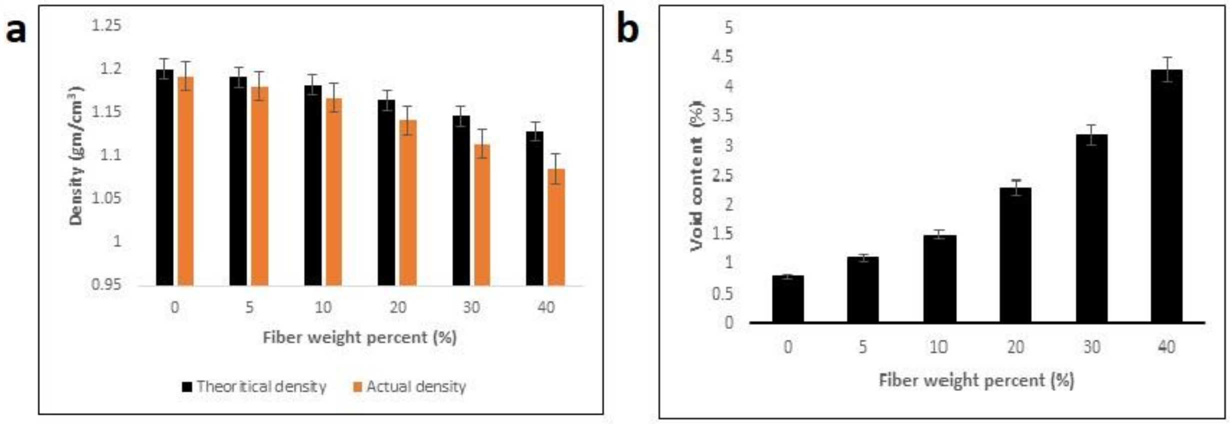

Fig. 3. (a) Variation of actual and theoretical density w.r.t. fiber percentage; (b) Variation of void content in specimens w.r.t. t fiber percentage.

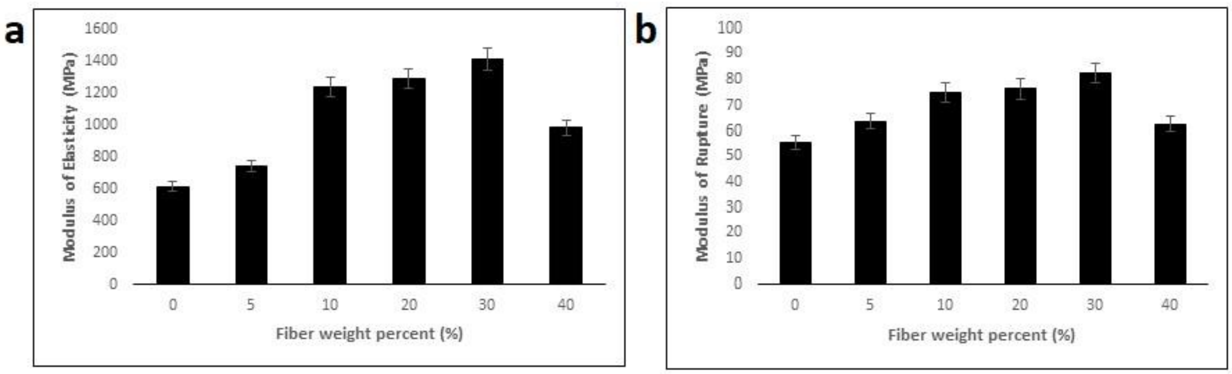

Fig. 4. (a) Variation of modulus of elasticity w.r.t. fiber percentage; (b) Variation of modulus of rupture w.r.t. fiber percentage.

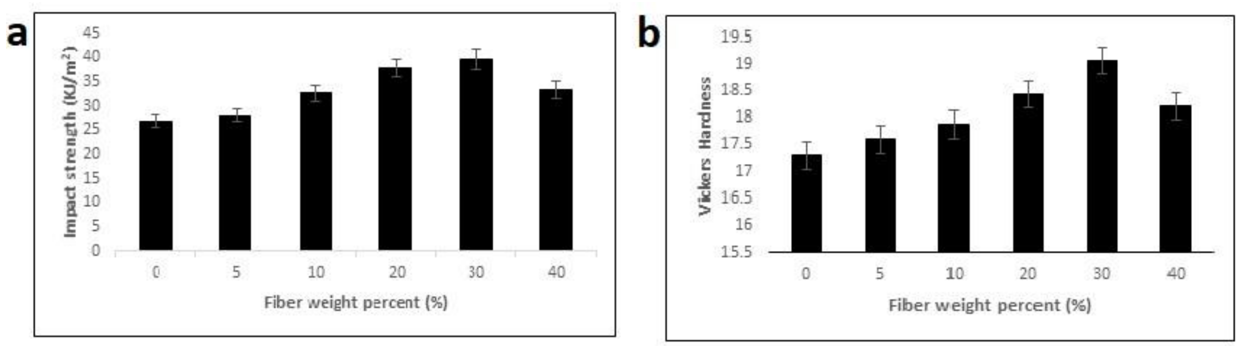

Fig. 5. (a) Variation of impact strength w.r.t. fiber percentage; (b) Variation of micro hardness w.r.t. fiber percentage.

3.1. Microstructure Analysis

For the identification of the mechanism of failure of the composite specimens, the fractured surface of the specimens was analyzed under SEM. The specimens were first coated with platinum in a vacuum environment with the help of a coating device to increase their conductivity before taking the photographs. The SEM observation reveals that the most of the material failure were due to the debonding of fiber at the matrix interface along with crack propagation. The tearing of fiber surface and pull out of the fiber for tensile and flexural tests are observed. Crack generation was found to be the major contributing factor for failure of composite in case of impact testing.

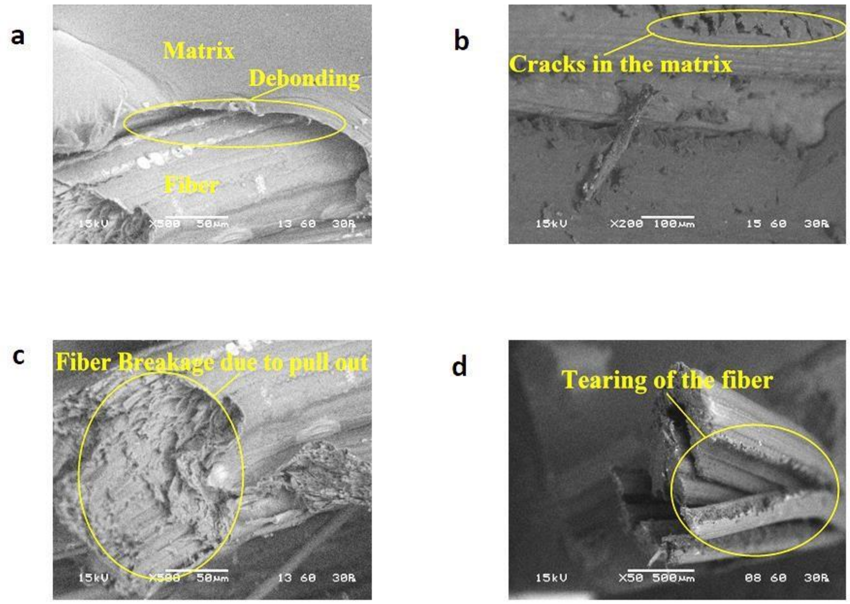

Fig. 6. (a) Matrix fiber debonding; (b) Micro cracks in the specimens;(c) Fiber breaking due to pull out;(d) Tearing of fiber.

4. Conclusion

- Eulaliopsis binate fiber is found to be a potential reinforcement for the polymer composites.
- The innate surface roughness proves to be a boon for the bonding between the matrix material and the fiber which gives better structural stability to the composite as a whole.
- In this investigation the addition of fiber lead to the gradual decrease in the actual density which points towards better specific mechanical properties.
- The short eulaliopsis binata fiber reinforced epoxy composites with different fiber weight percentage up to 40% were successfully fabricated by hand layup technique. Short fiber beyond 40 weight percent can be prepared due to decrease in matrix material which leads to low wetting of fibers.
- The mechanical properties of the composite with 30% weight fraction fiber was found to be optimal. Further incorporation of fiber caused the deterioration of the mechanical characteristics because of debonding of fiber from the matrix material.
- Chemical modification of fiber surface may increase the strength of the fiber as well as of the composite.

5. References

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