

## Synthesis and Analysis of Natural Fibers Reinforcement of Synthetic Resins

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### Abstract

Natural fiber Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. In this research the comparative synthesis and analysis of Kenaf fiber (FRPMC1) and Polmera fibers (FRPMC2) are treated with NaOH solution and the fibers are properly reinforced with polypropylene resin and epoxy resin respectively in a matrix form to prepare hybrid composite laminates of 6 mm fiber length thereafter to determine the mechanical properties like flexural strength, flexural modulus and tensile strength and tensile modulus with suitable specimens with ASTM D-638 and D-790 standards. The analysis was carried out by using FEA software for various loads and result factors. The surface is analyzed by SEM test with various resolutions. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. The surface is analyzed using when designed properly, the new combined material exhibits better strength than each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, and eco-friendly environmental applications.

**Keywords:** Kenaf fiber; Polmera fiber; Flexural strength; Tensile strength; SEM

### Introduction

The common fiber reinforced composites are composed of fibers and a matrix [1-3]. Fibers are the reinforcement and the main source of strength while matrix resins all the fibers together in a shape and transfers stresses between the reinforcing fibers. Sometimes, filler might be added to smooth the manufacturing process, impacts on special properties to the composites [4-6], and also reduce the product cost. In this research kenaf fiber and polmera fibers are treated with NaOH solution and the fibers are properly reinforced with polypropylene resin and epoxy resin respectively in a matrix form to prepare hybrid composite laminates of 6 mm thicknesses thereafter to determine the mechanical [7,8] properties like flexural strength flexural modulus, tensile strength, tensile modulus and compressive strength with suitable specimens with ASTM E-08 for tensile properties and ASTM D-790 for flexural properties as per standards. By using ANSYS through finite element analysis is done for various load and result factors. The surface is analyzed by SEM (Seismic electronic microscope) test with various resolutions from 200X, 500X, 1000X, 3000X and 5000X.

### Materials and Methods

Hibiscus Cannabinus has its Telugu vernacular name as "GOGU". The stalk of Kenaf plant consists of two distinct fibre types. The outer fibre is called "BAST" and comprises roughly of the 40% stalk's dry weight. The white inner fibre is called "CORE" and comprises 60% stalk weight. Kenaf fibres are extracted from the bast having a potential alternative as reinforcement in polymeric composites instead of synthetic fibres. Polmera fiber is a coir type fiber but having slight difference in physical and mechanical properties. This could be possibly a good alternative for coconut coir (Figures 1 and 2).

Polypropylene [1] is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as acrylonitrile butadiene styrene (ABS). Polypropylene is reasonably

economical, and can be made translucent when uncolored but is not as readily made transparent as polystyrene, acrylic, or certain other plastics. It is often opaque or colored using pigments. Polypropylene has good resistance to fatigue. The melting point of polypropylene occurs at a range, so a melting point is determined by finding the highest temperature of a differential scanning calorimetric chart. Perfectly isotactic PP has a melting point of 171°C (340°F). Commercial isotactic PP has a melting point that ranges from 160 to 166°C (320 to 331°F), depending on a tactic material and crystallinity. Syndiotactic PP with a



Figure 1: Polmera fiber.

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crystallinity of 30% has a melting point of 130°C (266°F). The melt flow rate (MFR) or melt flow index (MFI) is a measure of molecular weight of polypropylene.

Epoxy resin is known in the marine industry for incredible toughness and strength for bonding. Epoxy resin has a greater ability to flex and strain with the fibers without micro-fracturing and good resistant to water absorption. Epoxy bonds to all sorts of fibers very well and also offers excellent results in repair ability when it is used to bond two different materials together.

### Alkali treatment

The quality of a fiber reinforced composite depends considerably on the fiber-matrix interface because the interface acts as a binder and transfers stress between the treatments of fibers using chemical agent like sodium hydroxide (NaOH). For treatment process water by volume is taken along with 2% of NaOH. The fibers are soaked in the water for 24 hours as shown in Figure 3, and then the fibers are washed thoroughly with distilled water to remove the final residues of alkali. Good bonding is expected due to improved wetting of fibers with the matrix. In order to develop composites with better mechanical properties and good environmental performance, it is necessary to impart fibers by chemical treatments [9,10]. The extracted fibres treated untreated and chopped fibres as shown in Figures 3 and 4.

### Laminate preparation for specimens

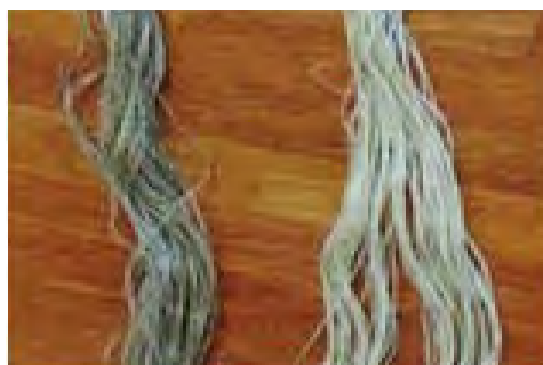
Compression moulding is a well-known technique to develop variety of composite products. It is a closed moulding process with high pressure application. In this method the matched metal moulder

used to fabricate composite product. In compression moulder the base plate is stationary while upper plate is movable. Reinforcement and matrix are placed in the metallic mold and the whole assembly is kept in between the compression moulder (Figures 5 and 6).

## Testings and Observations

### Flexural test specimen

Specimens for the flexural test are cut on a jig saw machine as per the ASTM standards. The dimensional details of each type of specimen are presented in respective diagrams [10]. Specimens are cut from laminas on a jig saw machine as per ASTM D790 standards. The standard regulated shaped specimens are used for testing. The dimensions of the flexural test specimen are shown in the Figure 7.



**Figure 4:** Showing treated, untreated fibers.



**Figure 2:** Hibiscus Cannabinus (Kenaf Plant).



**Figure 3:** Treatment of Fiber in 2% NaOH solution.



**Figure 5:** Kenaf + Polypropylene laminate (FRPMC1).



**Figure 6a:** Polmera + Epoxy laminate (FRPMC2).

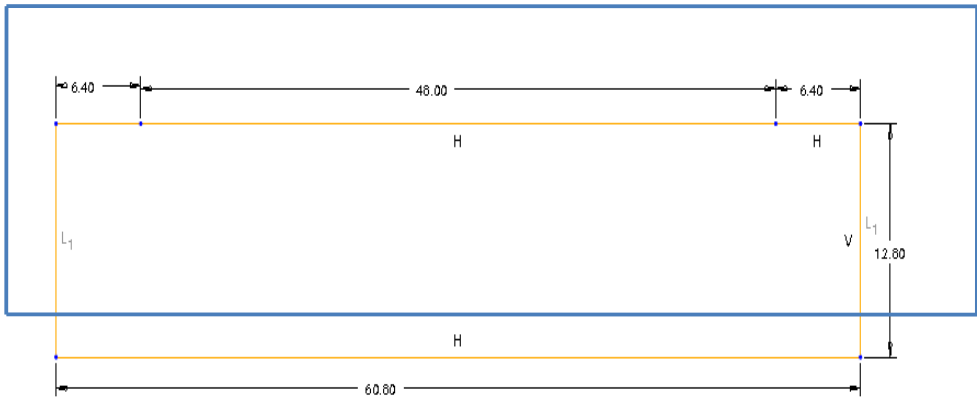
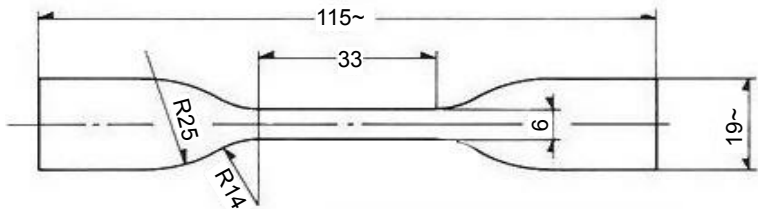


Figure 6b: Dimensions of a flexural test specimen.



All dimensions are in mm

Figure 7: Dimensions of tensile test specimen.

Tensile test specimen

Specimens for the tensile test are cut on a jig saw machine as per the ASTM standards the dimensional details of each type of specimen are presented in respective diagrams [9]. Specimens are cut from laminas on a jig saw machine as per ASTM D638 standards (Tables 1 and 2). The standards type 4 dumbbell shaped specimens are used for testing. The dimensions of the tensile test specimen are shown in the Figures 8 and 9.

Results and Conclusion

For the Tensile properties at the peak load, the tensile strength on polmera fiber with epoxy is 15.529 N/mm<sup>2</sup> which is less than the kenaf fiber reinforced with the polypropylene is 25.17 N/mm<sup>2</sup> while in compared with Md. Roshnal Hossain [2], the strength is 844 N/mm<sup>2</sup> but as an anisotropic material, jute fiber has a large scatter in tensile properties depending on test specimen span length, test machine slippage and presence of inherent and surface of defects, according to Buenaventurada P. Calabia [11] the tensile strength is 30 N/mm<sup>2</sup> cotton reinforced with poly(butylene succinate).

For the flexural properties at the peak load, the flexural strength is 125 N/mm<sup>2</sup> on polmera fiber with epoxy whereas in the kenaf fiber reinforced with the polypropylene is 88 N/mm<sup>2</sup>, while according to Byoung-Ho Lee [12] the flexural strength of 31N/mm<sup>2</sup> for the kenaf and polypropylene composite (Figures 10 and 11).

From the analysis it is observed that stress variation in the material shown by the different colors in the above image. The maximum stress is at red colour that is

$\sigma_{max} = 381.08\text{MPa}$

The minimum stress is at the green color section that is

$\sigma_{min} = 57.331\text{MPa}$

Specimen Description	Polmera with Epoxy	Kenaf with Polypropelene
Load at Peak (N)	3.345	4.5
Tensile Strength(N/mm <sup>2</sup> )	15.529	21.17
Load at Break(N)	3.27	5.8
% of Elongation	3.985	5.22
Tensile modulus(N/mm <sup>2</sup> )	528.5	796.2

Table 1: Tensile test observations.

Specimen Description	Polmera with Epoxy	Kenaf with Polypropelene
Flexural modulus(N/mm <sup>2</sup> )	4580	2322
Flexural strength(N/mm <sup>2</sup> )	125	88
Deflection(mm)	4	5
Peak load(N)	76	41

Table 2: Flexural test observations.

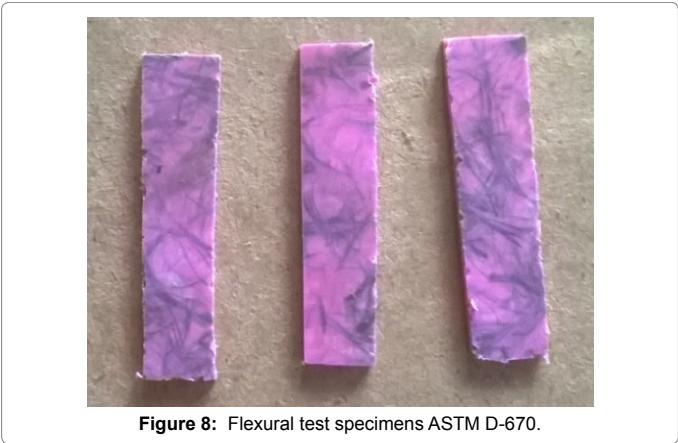


Figure 8: Flexural test specimens ASTM D-670.





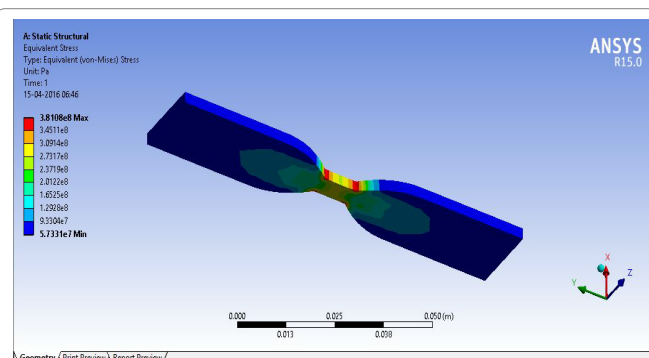
**Figure 9:** Tensile test specimen ASTM D-638.



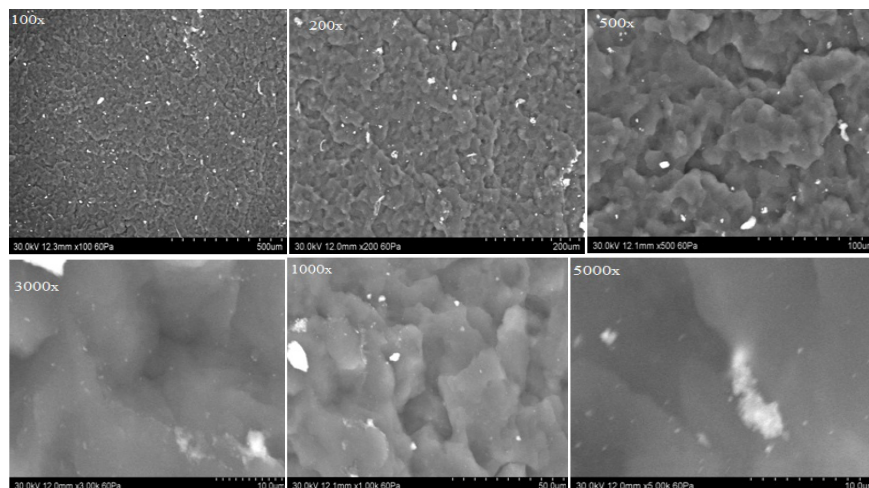
**Figure 10:** Flexural testing machine.



**Figure 11:** Tensile testing machine.



**Figure 12:** Equivalent stress of the composite specimen.



**Figure 13:** SEM analysis on the surfaces of the polypropylene resin with Kenaf fiber shows the fine distribution of fiber in resin in matrix with the required resolutions [8].

The actual value obtained by the calculations is less than the analysis value so the material Properties are accurate and accepted. It is concluded that the epoxy has far more to offer in its ability to flex, prevent delamination and ease of use for repair work. Using epoxy leads to better quality marine products (Figures 12 and 13).

The kenaf fibres were successfully used to fabricate composites with 30% fiber and 70% resin these fibres are bio-degradable and highly crystalline with well aligned structure. So it has been known that they also have higher tensile strength than other natural and synthetic composites and intern it would not induce any serious environmental problem like in synthetic fibers [12].

## Future Work

In the present investigation a compression moulding technique was used to fabricate the composites. However the results provided in this project can act as a base for the utilization of these fibers. Further work may be carried out to know the Dielectric properties of composites. Orientation of fibers may be considered to get the better mechanical properties. Design of experiment (DOE) can be used to get the optimum results.

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