Mechanical Properties of Natural Fibre [White Madar] Reinforced Polymer Composites

V.Ajith[1], Dr.P.K.Palani[2]

[1]*PG Scholar in Manufacturing Engineering,Government college of Technology ,Coimbatore,Tamilnadu, INDIA.*
[2]*Professor, Department of Mechanical Engineering Government college of Technology ,Coimbatore, Tamilnadu, INDIA*

Abstract - *Natural fibers play a very imperative role in the development of bio-degradable composites to fix the current environmental problems. In this investigation, the feasibility of applying renewable and eco-friendly white Calatropis gigantea fiber, composite as an alternate is studied.These extracted fibers are characterized by SEM, The chemical analysis indicates that white Calatropis gigantea fiber has significant cellulose content (69.65 wt. %) and less density (558 kg/m 3). The average crystalline index (CI) is observed as 56% and the morphological as well as surface roughness parameters justified that the white Calatropis gigantea fiber promotes significant bonding strength, while it is used as reinforcement in polymer composites. Various samples are prepared, tensile, compression and flexural tests are carried out. The results indicate that Calatropis gigantea fiber has better properties compared to glass fibre.*

Key Words: Bio-degradable composites;Calatropis gigantea fiber; Bonding strength; Crystalline index; Polymer composites.

1. INTRODUCTION

Composite is a structural material that consists of two or more constituents that are combined at macroscopic level and are not soluble in each other. The idea of combining several components to produce a material with properties that are not attainable with the individual components has been used by man for thousands of years. Almost all the material which we see around us is a type of composite. Natural fibres in simple definition are fibre's that are not synthetic or manmade. They can be sourced from plants or animals. The use of natural fibre from both resources, renewable and non-renewable such as oil palm, sisal, flax, and jute to produce composite materials, gained considerable attention in the last decades, so far. The plants, which produce cellulose fibres can be classified into bast fibres (jute, flax, ramie, hemp, and kenaf), seed fibres (cotton, coir, and kapok), leaf fibres (sisal, pineapple, and abaca), grass and reed fibres (rice, corn, and wheat), and core fibres (hemp, kenaf, and jute) as well as all other kinds (wood and roots. Advanced composites comprise structural materials that have been developed for high technology applications, such as airframe structures, for which other materials are not sufficiently stiff. In these materials, extremely stiff and strong continuous or discontinuous fibres, whiskers, or small particles are dispersed in the matrix. A number of matrix materials are available, including carbon, ceramics, glasses, metals,and polymers. Arthanarieswaran,[1] describes the evolution of five water soluble phenol resin as binders at 5 percent concentration, for oriented and random reinforced bagasse composite. They tried to determine the amount of resin retained during processing when these phenolics were precipitated on to bagassefiber. Madhu.,P.,M.R.Sanjay [2] tries to use the sugar cane bagasse waste as reinforcement to polymeric resins for fabrication of low cost composites. They reported that composites with homogeneous microstructures could be fabricated and mechanical properties similar to wooden agglomerates can be achieved. Kumar, R.,N. Rajesh Jesudass.[3] in their work reported the processing and properties of bagasse fiber-polypropylene composites. Four different chemical treatments were done on fiber to improve interface adhesion with the thermoplastic matrix namely isocyanine, acrylic acid, mercerization and washing with alkaline solution. Their result shows that the best results were obtained on materials with treated fibers. A.Kumaravel and S.S.Saravanakumar. [4, 5] have converted the bagasse into a thermo formable material through esterification of the fiber matrix. The dimensional stability and mechanical properties of the composites prepared from the esterifies fibers were reported in this work.Balasundar,P.[6] analyzed the impact strength and hardness of sugarcane bagasseresol composites and showed that impact strength increased and hardness diminished as the fiber volume fraction increased. Kommula,V.P[7] used short sugar cane fibers as reinforcement to obtain fiber reinforce composites. Lignin extracted from sugarcane bagasse was used as a partial substitute of phenol (40w/w) in resole phenolic matrices.They characterized the composite by mechanical tests such as impact, DMTA and hardness tests. The results as a whole showed that it is feasible to replace part of phenol by lignin in phenolic matrices without loss of properties.Manimaran; P. [8] studied the effect of three processing parameters on the flexural mechanical behavior of chopped bagasse poly-ester composite.

1.1 MATERIALS AND METHODS

The white Calotropis gigantea plant is a common wasteland weed. It is commonly known as calatropis gigantean/swallow-wort.Its binomial name is “Arka” in Sanskrit and “Madar” in English, native to India.It is flourishing up 13 feet and a small sized shrub with white stem and fair green leaves.The stem is useful for making ropes, fishing nets, sewing thread and carpets.Any solid that can bind and hold firmly the reinforcing phase in position within it is a potential matrix material for composite. The matrix used here is the Epoxy LY556 which is cost effective. Epoxy resins are the most commonly used thermoset resins in the world. More than 2 million tonnes of Epoxy resins are utilised globally for the manufacture of a wide assortment of products, including sanitary-ware, pipes, tanks, gratings and high-performance components for the marine and automotive industry. Epoxy resins are produced by chemical reaction of saturated and unsaturated di-carboxylic acids with alcohols. Epoxy resins form highly durable structures and coatings when they are cross-linked with a vinyl reactive monomer, most commonly styrene. The fibers are extracted and separated from the healthy and matured peeled bark of tender stems of the plant by Microbiological Retting/degumming process. Around one year old plants are suitable for the fiber extraction. The fiber extracted through this method has longer fiber length though it decreased during bleaching process. The extracted white Calotropis gigantea plant fibers were dried at ambient temperature for five days and used without chemical treatments. Epoxy LY556 of density 1.15–1.20 g/cm3, mixed with hardener HY951 of density 0.97–0.99 g/cm3 is used to prepare the composite plate. The weight ratio of mixing epoxy and hardener is 10:1. This has a viscosity of 10-20 poise at 250C. Hardners include anhydrides(acids), amines, polyamides, dicyandiamide etc.

Fig. 1. (a) White Calotropis gigantea plant (b) White Calotropis gigantea fiber extracted fibers from stem.

Composite plates are prepared with mixer of epoxy white Madar fiber and glass fiber. The weighted amounts of untreated fiber were taken, and cleaned the dust from fiber. The fiber was cut for length 3mm. The epoxy resin act as a bonding material of the composite plate. The fibers was varied as 10 %, 20 %, 30 %. Based on The rule of mixture the fiber and resin were mixed. The selected volume fraction of fiber and resin were mixing together based on rule of mixer. As like the, same procedure was followed for untreated fibers volume fraction of fiber. The combination of fiber and resin made a composite plate. The fiber and resin mixer pour in to the prepared die with respect to the height of composite plate. The short hammer used for ramming the fiber and resin mixer in the die. The upper plate was placed on the die plate were used applied pressure on the mould. The standard specimen used for tensile testing of continuous fibre composites is a flat, straight-sided coupon. The ASTM standard for tensile test is ASTM D 3039 and that of the specimen size is 250*25*3mm.Three point bend tests were performed in accordance with (ASTM) method D 790 [16] to measure flexural properties. The specimens were 100 mm long, 25 mm wide and 3 mm thick. In three point bending test, the outer rollers were 64 mm apart and samples were tested at a strain rate of 0.2 mm/min. Specimen were tested at a cross head speed of 2.5 mm/min, using associated universal testing machine (FIE) make. Flexural strength of the composite was calculated using the following relationship σf = 3PL/2bt2 Where of = stress in the outer specimen at midpoint, P = load at a given point on the load deflection curve, L = support span, b = width of the sample d = depth of the sample. Compression tests are used to determine a material’s behavior under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen (usually of either a cuboid or cylindrical geometry) using platens or specialized fixtures on a universal testing machine.

2. RESULTS AND DISCUSSION

The tensile test results were obtained for the various fibre percentages. Table 5.1 show the tensile test values. The tensile test results shows that maximum tensile strength of 44.24 MPa is obtained at 20 % fibre reinforcement of white madar fiber. The minimum tensile strength of 20.42 MPa is obtained for unreinforced composite. The tensile strength increases with increase in fiber percentage and then decreases

Table 1.1. Tensile test results

S.No	MATRIX (%)	FIBRE PERCENTGE (%)	TENSILE STRENGTH (MPa)
1	100	0	20.42
2	90	10	28.56
3	80	20	**44.24**
4	70	30	36.71

Table 1.2. Flextural test results

S.No	MATRIX (%)	FIBRE PERCENTGE (%)	COMPRESSIVE STRENGTH (MPa)
1	100	0	247.971
2	90	10	283.543
3	80	20	312.054
4	70	30	294.326

The flextural test results shows that maximum tensile strength of 349.014 MPa is obtained at 20 % fibre reinforcement of white madar fiber. The minimum flextural strength of 233.648 MPa is obtained for unreinforced composite. The tensile strength increases with increase in fiber percentage and then decreases. The compression test results were obtained for the various fibre percentages.

Table 1.3. Compression test results

S.No	MATRIX (%)	FIBRE PERCENTGE (%)	FLEXTURAL STRENGTH (MPa)
1	100	0	233.648
2	90	10	281.054
3	80	20	348.014
4	70	30	335.733

The compression test results shows that maximum tensile strength of 312.054 MPa is obtained at 20 % fibre reinforcement of white madar fiber. The minimum compressive strength of 247.971 MPa is obtained for unreinforced composite. The compressive strength increases with increase in fiber percentage and then decreases

3. CONCLUSIONS

The Natural fibre reinforced polymer matrix composites were fabricated successfully. From the experimentation results the following conclusions are made,

- The epoxy resin was reinforced with 10%, 20 % and 30 % white madar fibre.
- The samples were tested for its tensile strength, flexural strength and compressive strength.
- Tensile test results indicate, the tensile strength increases with increase in fiber percentage and then decreases maximum tensile strength of 44.24 MPa is obtained at 20 % fibre reinforcement of white madar fiber.
- The flexural test result shows that maximum tensile strength of 349.014 MPa is obtained at 20 % fibre reinforcement of white madar fiber. The tensile strength increases with increase in fiber percentage and then decreases.
- The compression test results show that maximum tensile strength of 312.054 MPa is obtained at 20 % fibre reinforcement of white madar fiber. The compressive strength increases with increase in fiber percentage and then decreases.
- Based on the test results, unreinforced composite exhibited lower strength.
- Maximum tensile strength, maximum flexural strength and maximum compressive strength was obtained for 20 % reinforcement of fiber.

The optimal fiber percentage is 20 % of white madar fiber.

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