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Comparison of Mechanical Properties of Natural Fiber Reinforced Polymer Composites

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ABSTRACT

Environment awareness and sustainability concept attracts researchers and scientist towards utilization of natural fibers as reinforcement in polymer based composites. Natural fibers will take a major role in the emerging 'green' economy. Natural fiber reinforced composites are attracting researchers due to their lower cost, light weight, renewability, lower density and high strength to weight ratio. Many recent researchers are undergoing in the field of natural fiber reinforced polymer composites due to the availability and eco-friendly source over conventional engineering materials. Various fibers are available for the reinforcement of polymer matrix, still researchers on new fiber identification for the reinforcement is needed to fulfill the requirements and also to utilize the availability of source for various engineering applications. In this paper fiber reinforced composi were prepared with petiole fiber and peduncle fiber. These prepared composites were tested and to study the mechanical properties of the composite such as tensile strength, flexural strength and impact strength. The results show that the mechanical properties of peduncle fiber reinforced composite have better and higher values while compare with the petiole fiber reinforced composites.

KEYWORDS: Natural Fiber reinforced composite, Mechanical Properties, Petiole fiber & Peduncle fiber.

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INTRODUCTION

The advantage of composites over their conventional materials is derived largely from its higher specific power, rigidity and low energy characteristics, which allows the structural design is more versatile. Significantly, the components of composite materials retain their personal, physical as well as chemical element properties still together produce a combination of qualities that the individual constituents would be unable to produce alone

COMPOSITE MATERIAL

A composite material is a composed of two or more physically distinct phases whose combination produces aggregate properties that are different from those of its constituents. Composites can be very important because of its strong and stiff, yet very light in weight, so ratios of strength to weight and stiffness to weight are several times stronger than steel or aluminum and also possible to achieve combinations of properties not attainable with metals, ceramics, or polymers alone. In the recent years, natural fibers reinforced composites are treated as most promising material in different application due to its attractive properties.

Phases of Composites

There are two phases of composite materials. They are matrix phase and reinforcement phase. They usually consist of high performance fibers as reinforcing phases and polymers or metal as matrices. The reinforcing material is imbedded in the matrix material to improve its mechanical and physical properties. Mechanical properties of composites vary according to the matrix and reinforced materials used are matrix phase and reinforcement phase.

Classifications of Composites

Composite materials are classified based on matrix material and material structure. Based on matrix material, composite materials are classified in to four groups such as Metal Matrix Composites (MMC), Ceramic Matrix Composites (CMC), Polymer Matrix Composites (PMC) and Carbon –Carbon composites (CCC).

Fibers and its Types

Fibers are the principal constituent in a fiber reinforced composites. They occupy the largest volume fraction in a composite structure and share the major load acting on it. Proper selection of the fiber type, fiber volume fraction, fiber length, and fiber orientation is very important in composites.

These are generally classified into two groups such as Synthetic Fiber and Natural Fiber. Fiber influences the following characteristics of composite structures are density, Tensile strength and modulus and Compressive strength and modulus.

Natural Fiber

Natural fibers are now dominate the automotive, construction and sporting industries by its superior mechanical properties. These natural fibers include flax, hemp, jute, sisal, coir and many others. The various advantages of natural fibers are low density, low cost, low energy inputs and comparable mechanical properties and also better elasticity of polymer composites reinforced with natural fibers.
The most used plant fibers are cotton, flax and hemp, although sisal, jute, kenaf, bamboo and coconut are also widely used. Hemp fibers are mainly used for ropes and aero foils because of their high suppleness and resistance within an aggressive environment. Hemp fibers are, for example, currently used as a seal within the heating and sanitary industries.

Shidharth D & Mayank J[1], Experiments were carried out to learning the produce of backbone extent on the mechanical behavior of these composite materials based epoxy polymer. These results indicate that coconut fibers can be used as a reinforcing material for many potential structural and non-structural applications. Preparing coir fiber polymer composite and examine the mechanical properties like tensile, impact and hardness.

Dinesh kumar Rao et al [2], Tensile and flexural behavior with characterization of hybrid bio-composite reinforced with walnut shell particles and coconut fibers: The tensile properties and flexural test of hybrid bio composite reinforced with walnut shell particle and coconut fiber were evaluated and analyzed.

Naveen PNE &Yasaswi M[3], Coir composites are developed and their mechanical properties are evaluated, at five different volume fractions and lengths. Experimental results showed tensile, static and Dynamic properties of the composites are greatly influenced by the increasing percentage of reinforcement, lengths of the fiber and indicate coir can be used as potential reinforcing material for many structural and non structural applications.

Mulinari et al[4], A composite material is a multi phase material that is artificial made as opposed to one that occurs or forms naturally. Composite material exhibits a significant proportion of both the

constituent phases such that a better combination of properties is realized. Fabrication of polyester composite and test the mechanical properties.

Harish S et al[5], the fiber which serves as a reinforcement in reinforced plastics may be synthetic or natural. Past studies show that only artificial fibers such as glass, carbon etc., have been used in fiber-reinforced plastics. These results indicate that coir can be used as a potential.

Fahim et al[6],The removal of impurities and waxy substances from fiber surface avoid creation of rougher topography after treatment and improves the quality of fiber, also content of hemi cellulose and lignin decrease so increase effectiveness of fiber due to dispersing of fiber in matrix. The reinforcing material is embedded in the matrix material to enhance tensile and flexural behaviors of the synthesized composite.

Gopinath et al[7], The prepared composites were tested to study the mechanical properties of the composite such as tensile strength, flexural strength, impact strength and hardness. The results show that the jute reinforced epoxy composite exhibited better mechanical properties than Jute-polyester composite.

Ashik KP et al[8],Natural fibers have recently become attractive to researchers and scientists as an alternative method for fibers reinforced composites. This review paper summarized the history of natural fibers and its applications. Also, this paper focused on different properties of natural fibers.

In this paper, the mechanical properties of natural fiber reinforced polymer composites like tensile strength; flexural strength and impact strength are having better result than the fiber reinforcement polymer composite. Also the mechanical properties are depending upon the weight proportions of the reinforcement. The composite materials of natural fibers are giving high mechanical properties. The mechanical properties are depending upon the ratio proportion of mixing the fibers, individual properties of the fibers and resin. Many industrial companies are looking for new composites material which has good and specific properties like mechanical, chemical and dynamic characteristic.

MATERIALS AND METHODS

Natural fibers are a kind of renewable resources, which have been renewed by nature and human ingenuity for thousands of years. They are also carbon neutral; they absorb the equal amount of carbon dioxide they produce. These fibers are completely renewable, environmental friendly, high specific strength, non-abrasive, low cost, and bio-degradability. Natural fibers were initially used in composite materials to predominately improve bulk and reduce cost rather than improving mechanical properties. In searching for new material, a study has been made to find new natural fiber from coconut tree composite material.

Materials Used

The present work has been undertaken to develop a new polymer matrix composite of fibers from coconut peduncle and petiole coconut fiber as reinforcement and polyester resin as matrix.The stalk that attaches a single flower, flower cluster, or fruit to the stem is called Peduncle. A stalk supporting an inflorescence, which is the part of the shoot of seed plants, where flowers are formed, is also called peduncle.

The petiole is the pipeline through which the products of photosynthesis are moved from individual leaves to the rest of a plant and through which necessary chemicals and nutrients from other parts of the plant (e.g., nutrients absorbed through the roots) are brought to individual leaves.

Figure 1 Coco's Petiole and Peduncle

Polyester Resin

The starting material for a thermo set polyester matrix is an unsaturated polyester-resin that contains a number of C=C double bonds. It is prepared by the reaction of maleic anhydride and ethylene or propylene glycol. This is an extremely versatile, fairly inexpensive, polymer, unsaturated polyester combines an unsaturated dibasic acid and a glycol dissolved in a monomer, generally, styrene, including an inhibitor to stabilize the resin. Organic peroxides, such a methyl-ethyl ketone peroxides (MEKP) and a promoter is combined with the resin to initiate a room temperature cure.

In this liquid state, polyester may be processed by numerous methods, including hand lay-up, vacuum bag molding, spray up and compression molded sheet molding compound, etc. In combination with certain fillers they can exhibit resistance to breakdown under electrical arc and tracking conditions, Isophthalic polyester resins exhibit higher thermal stability, dimensional stability and creep resistance. In general, for a fiber-reinforced resin system, the advantage of polyester is its low cost and its ability to be processed quickly.

Polyesters can be formulated to cure more rapidly than do Phenolic during the thermo set molding process. While Phenolic processing, for example is dependent on a time/temperature relationship, polyester processing is primarily dependent on temperature.

The catalyst is added to drive the reaction. Usually, the catalyst is methyl ethyl ketone (MEK) or benzoyl peroxide. The polyester resin and the styrene solvent react together to crosslink, or polymerize, to form a film. The polyester resin system will not cure properly if the appropriate quantity of catalyst is not added.

The advantages of the polyester resin are as follows:
Essentially two components in one container long lasting and durable, does not discolor badly and relatively inexpensive.

Fiber Extraction Process

In peduncle and petiole fibers have been extracted from chemical treatment process instead of manual stripping process. The reasons for chemical extraction are

- In chemical extraction gives fineness of fiber is high compare than mechanical or manual stripping
- Chemical extraction reaction easily to achieve long fiber
- Breakage of fiber is negligible when compare mechanical stripping
- The lead time was reduced by using chemical extraction when compare water retting, mechanical and manual stripping
- Accuracy of extraction is good when compare other methods.

Materials for Chemical Treatment Process

The following chemicals such as sodium hydroxide, sodium benzoate and hydrogen peroxide are used to prepare the chemical solution at different concentration. In peduncle and petiole fibers have been extracted from the coconut tree by using these chemical solutions.

METHODOLOGY

The fibers have been extracted from the peduncle and petiole of the coconut tree by retting process. Retting which is the process of separating fibers from non-fiber tissues in plants, involves bacteria and fungi treatments and mechanical and chemical process for fibers extraction. Good quality of fibers, dew retting is usually replaced by other more economic methods because the process is very time consuming and weather dependent.

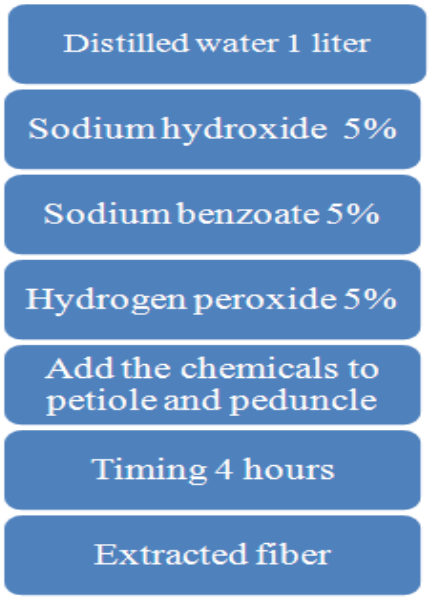

Figure 2. Steps Involved in Extraction Process

RESULTS AND DISCUSSION

In this paper, pedunclefibers and petiole fiber are prepared as reinforced polymer composites. Then the test specimens are prepared from the composites as per ASTM standards and testing of materials has been carried out under tensile, flexural and loading conditions by using universal testing machine.

Tensile Strength Analysis

The tensile properties of the natural reinforced fiber composite samples are tested and the experimental values are presented in the table

Table 1 Comparisons of Tensile Strength

S.No	Name of the Fiber and Resin	Fiber Weight (%)	Tensile Strength (MPa)
1	Pure Polyester Resin	0	10.18
2	Peduncle Fiber	10	12.85
3	Petiole Fiber	10	12.57

The result shows that the peduncle fiber composite have the highest tensile strength values compared with the pure polyester resin and petiole fiber.

Flexural Strength Analysis

The flexural properties of the natural reinforced fiber composite samples are tested and the experimental values are presented in the table no.2.

Table 2 Comparisons of Flexural Strength

S.No	Name of the Fiber and Resin	Fiber Weight (%)	Flexural Strength (MPa)
1	Pure Polyester Resin	0	18.43
2	Peduncle Fiber	10	25.45
3	Petiole Fiber	10	21.38

The result shows that the peduncle fiber composite has the highest flexural strength values compared with the pure polyester resin and petiole fiber.

Impact Strength Analysis

The impact properties of the natural fiber reinforced composite samples are tested and the experimental impact strength values are presented in the table3.

Table 3 Comparisons of Impact Strength

S.No	Name of the Fiber and Resin	Fiber Weight (%)	Impact Strength (MPa)
1	Pure Polyester Resin	0	15
2	Peduncle Fiber	10	19
3	Petiole Fiber	10	17

The result shows that the peduncle fiber composite has the highest impact strength values compared with the pure polyester resin and petiole fiber.

CONCLUSION

In this paper, the extraction fibers from peduncle and petiole were done by using the multilevel chemical treatment with various stages such as mechanical stripping, water treatment and chemical treatment. Then the extracted peduncle and petiole fibers specifications were measured and extraction time was minimized by adding different concentration of chemical solutions. This paper shows that successfully fabrication of natural fiber reinforced polyester composites with different proportions is possible by hand molding technique. It has been noticed that the mechanical proportions of composites such as flexural test, tensile strength and impact strength of the composites are greatly influenced in for different weight fraction of the fiber. The results of mechanical properties are tensile strength, flexural strength and impact strength shows that peduncle fiber composite values are higher than petiole and pure polyester resin composite.

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