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RESEARCH ARTICLE

REVIEW ON EFFECT OF FIBER TREATMENT ON MECHANICAL PROPERTIES OF NATURAL FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT

The natural fiber-reinforced polymer composite is capturing view in many industrial applications like automotives and many other human centric oriented frugal innovation products and fundamental research. Fiber reinforced polymer composites have a wide variety of applications as a class of structural materials because of their advantages such as ease of fabrication, relatively low cost of production & superior strength as compared to neat polymer resins. The fiber which serves as a reinforcement in polymers may be either synthetic or natural. Although synthetic fibers such as glass, carbon, nylon, polyester etc [1]. Possess high specific strength; their fields of applications are limited because of their higher costs of production. Recently, there is an increasing interest in hybrid composites that are made by reinforcement of two or more different types of fibers in a single matrix, because these materials attain a range of properties that cannot be obtained with a particular kind of reinforcement. Further, material costs can be reduced by careful selection of reinforcing fibers. Natural fibers have been proven substitute to synthetic fiber in transportation domain such as automobiles, railway coaches and aerospace because of their low thermal expansion, high tensile strength, high strength to weight ratio. Other applications include military, building, packaging, consumer products and construction industries for ceiling paneling, partition boards [2]. Currently, the Mechanical treatments of the fibers are carried out as they further enhance the properties of the composites. This paper deals with review of fiber treatment on mechanical properties of different natural fibers reinforced polymer composites.

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INTRODUCTION

The term composite can be defined as a material laminated by two or more different materials, with the properties of the resultant material being superior to the properties of the individual material that make up the laminated composite. Glass Fiber Reinforced Polymers (GFRPs) is a fiber reinforced polymer made of a plastic matrix reinforced by fine fibers of glass. Fiber glass is a lightweight, strong, and robust material used in different industries due to their excellent properties. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are very favorable when compared to metals, and it can be easily formed using molding processes.

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Now a day's natural fiber such as sisal and jute fiber composite materials are replacing the glass and carbon fibers owing to their easy availability and cost. Several researches have been taken place in this direction. Most of the studies on natural fibers are concerned with single reinforcement. The addition of natural fiber to the glass fiber can make the composite hybrid which is comparatively cheaper and easy to use. In recent years, the interest of scientists and engineers has turned over on utilizing plant fibers as effectively and economically as possible to produce good quality fiber-reinforced polymer composites for structural, building, and other needs. It is because of the high availability and has led to the development of alternative materials instead of conventional or man-made ones. Many types of natural fibers have been investigated for their use in polymer such as wood fiber (Maldas *et al.,* 1995) (Li *et al.,* 2009), sisal (Joseph *et al.,* 1999), kenaf (Rowell *et al.,* 1999), pineapple (Mishra *et al.,* 2001), jute (Mohanty *et al.,* 2006), banana (Pothan *et al.,* 2003) and straw (Kamel 2004). Bax and Mussig 2008 investigated the mechanical

properties of PLA reinforced with cordenka rayon fibers and flax fibers. In the present study the mechanical properties of natural fiber reinforced composite materials is studied. The properties such as tensile, compression, flexural and impact are studied and presented in detail.

Classification of Natural Fibers

Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope. They can be used as a component of composites materials. They can also be matted into sheets to make products such as paper or felt. Fig 2.1 shows classification of Natural fibers.

Natural Fibers

Animal Fibers	Plant Fibers	Mineral Fibers
Animal Hair	Bast Fibers	Ceramic Fibers
Silk Fibers	Grasses and Reeds	Asbestos
Chicken Feather	Wood Fibers	Metal Fibers
Avian Fibers	Fruit Fibers	
	Seed Fibers	
	Leaf Fibers	

Fig 2.1. Classification of Natural fibers

Hybrid Composites

When more than one type of fibers are reinforced into a common matrix, the resulting composite is called hybrid composite. Hybrid composites provide greater freedom when it comes to designing composites for specific properties as compared to single fiber reinforced composites. Recently, natural fibers such as bamboo, jute etc. have been mixed with synthetic fibers such as glass to form hybrid composites with desired properties at low cost.

The behavior of hybrid composites is a weighed sum of individual components in which there is a more favorable balance between the inherent advantages and disadvantages (Verma *et al.,* 2013). Using hybrid composites, the advantages of one type of fiber could compliment what is lacking in the other fiber. The properties of hybrids are decided by many factors such as fiber content, fiber length, orientation, extent of intermingling of fibers, fiber to matrix bonding etc. And various properties of natural fibers are tabulated as below.

Fiber Treatment

In this study, chemical resetting was used. The procedure involves NaOH solution treatment, water washing and drying. Natural fibers are extracted from their parent plant. The ukam, sisal and banana are extracted from the back of their stems, while hemp and coconut are extracted from their fruits. The natural fibers, after being extracted, are washed with water to remove gums. The fibers are then treated with sodium hydroxide solution and rammed. The treated fibers was allowed to dry in the sun for 3 days. After which the fibers are laid in the mold with the resin at the ratio of 30% to 70%. It was allowed to cure for about 20 days (Chadramohan and Marimuthu, 2011).

Alkali treatment

The fibers were treated using a 2% aqueous solution of NaOH (by weight). The fibers were soaked in the solution for 3hours. Subsequently, the fibers were washed 6 times with distilled water and oven dried at 80°C for 24hours (Li *et al*., 2009).

pMDI chemical treatment

Kenaf was pre-treated with 4% pMDI by weight of the fiber as follows. First, kenaf was mixed with toluene in a flask. Then, pMDI was mixed with toluene in a dropping funnel and then dropped into the flask over 20minutes (Athijayamani *et al*., 2009). The flask was heated at 50°C on a flat heater with continuous mixing for one hour. After the treatment, the treated fibers were separated by filtration, washed several times with toluene and dried in an oven at 70°C for 2hours.

Table 2.2. Properties of natural fibers (Verma *et al.*, 2013)

Fiber	Tensile strength (MPa)	Young's modulus (GPa)	Elongation at break (%)	Density (g/cm^3)
Abaca	400	12	3-10	1.5
Alfa	350	22	5.8	0.89
Bagasse	290	17	-	1.25
Bamboo	140-230	11-17	-	0.6-1.1
Banana	500	12	5.9	1.35
Coir	175	4-6	30	1.2
Cotton	287-597	5.5-12.6	7-8	1.5-1.6
Curaua	500-1,150	11.8	3.7-4.3	1.4
Date Palm	97-196	2.5-5.4	2-4.5	1-1.2
Flax	345-1,035	27.6	2.7-3.2	1.5
Hemp	690	70	1.6	1.48
Henequen	500+70,500-70	13.2+3.1,13.2-3.1	4.8+1.1,4.8-1.1	1.2
Jute	393-773	26.5	1.5-1.8	1.3
Kenaf	930	53	1.6	-
Oil Palm	248	3.2	25	0.7-1.55
Pineapple	400-627	1.44	14.5	0.8-1.66
Ramie	560	24.5	2.5	1.5
Sisal	211-635	9.4-22	2.0-2.5	1.5
E-Glass	3400	72	-	2.5

Mechanical Testing of Natural fiber Reinfored Composites

Testing of samples for tensile and compressive strengths were done on Computerized Universal Testing Machine (HOUNSFIELD H25KS) and wear testing was done on Wear and Friction Monitor (DUCOM-TR-20L) (Fávaro *et al*., 2010).

Tensile strength test

The tensile strength test was conducted on Computerized Universal Testing Machine (HOUNSFIELD H25KS). The sample of 10 cm length was clamped into the two jaws of the machine. Each end of the jaws covered 2 cm of the sample. Tensile strength was studied over the rest of 6 cm gauze length. Reading of the tensile strength test instrument for Newton force and extension was initially set at zero. The test was conducted at the constant strain rate of the order of 10 mm/min. Tensile stress was applied till the failure of the sample and load-extension curve was obtained. Each sample was tested for five times and average results have been reported.

Compressive strength test

Compression strength of samples was also tested on Computerized Universal Testing Machine (HOUNSFIELD H25KS). Composite sample was held between the two platforms and the strain rate was fixed at 10 mm/min whereas the total compression range was 7.5 mm. The compression stress was applied till the failure of sample. Total compression per unit force was noted.

Wear test

The wear test of the testing sample was conducted by Wear & Friction Monitor (DUCOMTR-20L). The disc was cleaned with emery paper and it was fixed at 500 rpm. The inner diameter of steel disc was 80 mm. Initial weight of the sample was noted and the sample pin was fixed in the jaws of wear testing machine. Then machine was set to display zero wear and friction. The samples were tested with different loads varying from 1–3 kg. For each load the machine was allowed to run for 15 min and the readings were recorded. After 15 min the sample was taken out from the machine and weighed again. Then loss in weight due to abrasion was calculated and this weight loss was used as the measure of wear.

Thermal analysis of samples

Thermal analysis of natural and synthetic polymers gives us good account of their thermal stability. Thermal analysis comprises of various methods such as thermo gravimetric analysis (TGA)/differential thermal analysis (DTA), derivative thermo gravimetry (DTG) etc. Thermo gravimetric analysis (TGA) and differential thermal analysis (DTA) studies of samples were carried out in nitrogen atmosphere on a thermal analyser (Perkin Elmer) at a heating rate of 10°C/min. TGA was used to characterize the decomposition and thermal stability of materials under a variety of conditions, and to examine the kinetics of the physico-chemical processes occurring in the sample.

Basically in this method a change in thermal stability was examined in terms of percentage weight loss as a function of temperature. The mass change characteristics of a material were strongly dependent on the experimental conditions such as sample mass, volume, physical form; shape and nature of the sample holder, nature and pressure of the atmosphere in the sample chamber and the scanning rate, all have important influences on the characteristics of the recorded TG curve. At the same time, DTA involves comparing the precise temperature difference between a sample and an inert reference material, while heating both. DTG is a type of thermal analysis in which rate of material weight changes upon heating vs temperature is plotted and is used to simplify reading of weight versus temperature thermogram peaks that occur close together. DTG peaks are characterized by the peak maximum (Tmax) and the peak on set temperature (Te). The area under DTG curve is proportional to the mass change and the height of the peak at any temperature gives the rate of the mass change at that temperature. DTG curves are frequently preferred when comparing results with DTA curves because of the visual similarity.

RESULTS AND DISCUSSION

The importance of static mechanical analysis (SMA) as a tool in the study of the behaviour of polymer bio composites is of paramount importance. It has been proved to be an effective method to study the behaviour of materials under various conditions of tension, compression, stress– strain, and phase composition of fibers composites and its role in determining the mechanical properties. Static mechanical properties of fibers reinforced composites depend on the nature of the polymer matrix, distribution and orientation of the reinforcing fibers, the nature of the fibers – matrix interfaces and of the interphase region.

Tensile strength

The ability of a material to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength or tensile strength at break.

Compressive strength

The ability of a material to resist breaking under compression stress is also one of the most important and widely measured properties of materials used in various applications. The value of uniaxial compressive stress reached when the material fails completely is designated as the compressive strength of that material. The compressive strength is usually obtained experimentally by means of a compressive test. The apparatus used for this experiment is the same as that used in a tensile test.

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