

RESORCED NATURAL FIBER COMPOSITE'S POTENTIAL ENHANCEMENT

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ABSTRACT

To create and evaluate cost-effective high strength material technologies that might drastically lower the weight of the product without compromising cost, performance, or safety issues, materials innovation and application have become more and more important in recent years. Natural fiber polymeric composites have advanced from basic research conducted at the laboratory scale to commercial use. Thermoplastics, as opposed to thermosets, are taken into consideration in this study due to their many benefits without compromising their traditional values, such as their high impact strength, recyclable nature, environmental friendliness, ease of converting waste into valuable materials, and added benefit of not producing volatiles during processing. A number of biodegradable resins and diverse fibers are examined from the standpoint of the efficient use of natural fiber reinforced plastic (NFRP), and additional comparisons of different fiber properties are made. This paper gives an overall view of different natural fibers its technical comparisons, selection of best binders, coupling agents which suits the fiber and discussed about the development possibilities in the future.

Keywords: *Natural Fiber Reinforced Plastic, Synthetic fibers, Thermoplastic, Thermosetting plastic, Interfacial bonding, Resins, Composites, Elastomers.*

INTRODUCTION

The past several decades have seen a revolution in material science due to advancements in the field of natural fiber-polymeric composites, with particular effects on the automotive, aircraft, marine, manufacturing, and construction industries. The creation of natural fiber materials piques our curiosity because of ecological limitations. It started out as laboratory research and has since been successfully applied in a variety of industrial sectors due to its recyclable nature and environmental friendliness, which pave the way for the introduction of new, inexpensive, light-weight materials with good intrinsic mechanical characteristics. While synthetic fibers such as glass and carbon fibers have a high specific strength and are rarely employed due to their higher manufacturing costs, natural fibers can be used as an alternative to synthetic materials.

Fiber (either natural or synthetic) is the primary component of fiber reinforced plastic, or FRP. For fiber-reinforced plastics, both natural and synthetic fibers have been utilized, such as glass, aramid, carbon, and vegetable fibers including flax, hemp, jute, sisal, bamboo, and kenaf. As opposed to animal-derived fibers, which are made up of proteins (such as hair, silk, and wool), vegetable fibers are divided into three categories: bast (jute, banana, cotton, flax, hemp, kenaf), leaf (pineapple, sisal), and seed or fruit fibers (coir, cotton, oil palm). (Wagner, 1961; Flemming et al., 1995; Satlow et al., 1994; Haudek and Viti, 1980). Cellulose is the main component of the vegetable fibers. Fibers of sisal, bamboo and banana extracted by retting and manual processes have been used to fabricate the composites. (K. Murali Mohan Rao et al., 2009) [15]; Despite the fact that plastics are too pliable and soft in comparison to fibers, when they come together to create a composite material, a high strength-to-weight ratio is produced. This is achieved by having as many fibers with a large length as feasible and as small of a diameter as feasible. optimal polymer and cellulosic fiber mixing that prevents the natural fiber from being drastically shortened, giving the finished composite its strength and stiffness. Although natural fibers are less desirable for external applications because of their poor resistance to moisture absorption, advances in material science are being made possible by a variety of chemical treatments, such as acetylation, which improves dimensional stability by reducing moisture absorption, and additive additions.

POLYMERS

The most common materials include thermoplastics like polyethylene (PE), polystyrene (PS), and polypropylene (PP) and thermoset polymers like polyester, phenolics, and epoxies. These materials differ in their attraction for fiber due to their chemical makeup. Due to the higher strength/modulus ratio and higher matrix ductility of sisal in comparison to the LDPE matrix, sisal/LDPE composites demonstrated a superior reinforcing effect. The tensile characteristics of the resultant composites were found to be improved by benzylation of sisal fiber. In polyester, epoxy, and phenol formaldehyde composites, the addition of sisal fiber significantly lowered the glass transition temperature of polystyrene. Because phenolic composites have a strong interfacial bonding, phenolic type resin performs better as a matrix in terms of tensile and flexural capabilities than epoxy and polyester resins. (Jayamol George et al., 2001) [2]. Short sisal fibers bonded with polypropylene were used to create a composite using melt and solution mixing techniques. By adjusting the mixing time, rotor speed, and chamber temperature, the melt-mixing technique's mixing parameters were tuned. The best mixing conditions were determined to be a mixing temperature of 170°C, a rotor speed of 50 rpm, and a mixing time of 10 minutes. Melt-mixed composites outperformed solution-mixed composites in terms of tensile characteristics when the mixing circumstances were ideal. (Kuruvilla et al., 1999; P. V. Joseph). The finest qualities in composites are produced by either a thermosetting or thermoplastic matrix combined with reinforcing fibers. Due to their great dimensional stability and higher heat deflection temperature (HDT) of up to 140°C, natural fibers with thermoplastic matrix have several applications, it has less abrasive nature when compared with aramid, glass fibers, it can be easily reduce to ashes and is eco- friendly when compared with glass fibers, it wont create any health hazards to persons working with.

INTERFACIAL BONDING

Research on the kinetics of crystallization was done on composites by Chen and Porter. They found that in order to effectively distribute stress and load throughout the fiber/polymer interface, kenaf fiber—which is taken from the bast of the Hibiscus cannabinus plant—must form a strong adhesion at the interfaces. Natural fibers have an uneven and rough surface, which promotes good fiber-matrix bonding and adherence to the matrix in composite structures. In terms of interfacial bonding, the polymeric waxy layer also showed a greater influence. A coating, usually consisting of coupling agents or compatibilizing agents that form chemical links between the fiber and matrix, is applied to composites to increase their mechanical properties.

The physical and mechanical properties of composites are greatly influenced by the fiber/matrix interfacial bonding. Therefore, in order to improve the interfacial properties, the moisture content of the natural fiber must be removed before beginning the process. This can be done by heating the fiber to 80 degrees Celsius for a few hours. After that, the fiber can undergo various chemical treatments, including acrylation, acetylation, dewaxing, mercerization, bleaching, cyanoethylation, silane treatment, benzoylation, peroxide treatment, isocyanate treatment, acrylation, acetylation, latex coating, steam-explosion, etc. (M. Brahmakumar et.al., 2005)). [16] The standard process for producing high-quality fibers from natural and artificial impurities is to treat natural fibers (NFs) with alkali, also known as mercerization. This process causes the fiber bundle to fibrillate into smaller. Graft copolymerization NFs; consist of orderly arranged grafted segments, which act as compatible reinforcing fibers with several resin systems to obtain better fiber–matrix adhesion of the resulting eco-composites. Isocyanates provide better interaction with thermoplastics resulting in superior properties. Isocyanates could act as a promoter, or as an inhibitor of the interaction. The grafting of polyethylene onto cellulose surfaces by peroxide is responsible for the improvement in mechanical properties. Because of the improved adhesion, fiber-surface silanization led to a superior interfacial load transfer efficiency. The fibers' surface energy is raised, which improves their wettability and increases interfacial adhesion. As coupling agents, a wide variety of additional substances can be employed, including titanates and chromium complexes. The deposition of a monolayer of organ functional titanate reduced the water of hydration, improving the dispersion and compatibility at the interface, according to research on the processing of composites using titanate coupling agents.

PROPERTY ENHANCEMENT

Physical treatments alter the fiber's surface and structural characteristics, which has an impact on how well it mechanically bonds to the matrix. Utilizing components such as electron, ion, radical, and excited molecules produced by electrical discharge, low temperature plasma generated under atmospheric pressure in the presence of helium is a useful approach to improve the surface characteristics of fiber and polymeric materials. To improve the mechanical properties of composites and reduce the melt viscosity of cellulose-polyethylene composites, electrical discharge methods are employed for cellulose fiber modification. Hydrophobic polymers are incompatible with strongly polarized cellulose fibers by nature. By generating a hydrophobic coating of a suitable polymer on the filler surface, it is possible to improve the

dispersibility and compatibility of the fiber with the matrix. (Jayamol George et al., 2001) [2]. In the course of the reaction, the coupling agents have two purposes: they react with the hydroxyl groups in cellulose and with the matrix's functional groups. For a composite material, it is crucial to choose a coupling agent that can effectively combine toughness and strength. Silane, isocyanate, and titanate-based chemicals are the most often used coupling agents. They can react with the fiber surface due to their chemical makeup, creating a bridge of chemical linkages that connects the fiber to the matrix. Isocyanates were shown to be dependable when it came to cellulosic fiber composites. The creation of covalent bonds between cellulose and isocyanate, or primary type bonds, and secondary type bonds is anticipated. Pretreatment of fibers through grafting, encapsulating coating with isocyanates or silanes, etc., reduces the contact between the fibers and the coating that forms on the fiber surface, improving dispersion. By creating a siloxane bridge to make a chemical bond with the cellulose's surface and an organofunctional group bonding with the polymer resin, bifunctional silane molecules work as a bridge between the cellulose and the resin. Molecular continuity is provided throughout the composite's interface region by this co-reactivity with the polymer and cellulose through covalent primary bonds. The interfacial adhesion and, consequently, the mechanical characteristics of the composites are greatly enhanced when silane coupling agents are applied to the fibers. After silane treatment of fiber, the surface roughness of the fibers are increased considerably when compared to untreated fiber. Isocyanates, especially poly(methylene) poly(phenyl) isocyanate (PMPPIC), are well known wood binders.

Natural fibers have a wide range of mechanical and physical characteristics based on their chemical and structural makeup, kind, and growth environment. The adhesion between the matrix and the fibers is the primary factor influencing the mechanical characteristics of composite materials. The adhesion qualities can change if the fibers are pretreated. As a result, unique processing techniques like chemical and physical alteration techniques are created. Through better fiber and polymer combination—achieving the increased fiber-matrix adhesion by impregnating the reinforcing fibers with polymer matrices suitable with the polymer—a higher damage resistance under cyclic dynamic loading is produced. To strengthen the binding at the fiber/polymer interface, experiments were conducted using chemicals such as sodium hydroxide, maleic anhydride, and permanganate. Cellulosic material, which was either precoated with an isocyanate polymer mixture or the isocyanate, was added directly into the mixture of fiber and polymer. Urethane derivatives of cardanol were treated with sisal fiber to improve the compatibility between fiber and matrix. The urethane derivatives of cardanol is the principal component of cashew nut shell liquid and toluene di-isocyanate, the (PMPPIC) treatment has significant influence on the properties of composites, i.e., increased thermal stability, reduced water absorption etc.

MORPHOLOGICAL STUDY

Atomic force microscopy is a valuable method to ascertain the surface roughness of fibers; X-ray photoelectron spectroscopy offers insight into the quality of the interfacial bond as well as the bond's performance throughout service. Its benefits, which include high resolution and non-destructivity, present a special opportunity for repeated inspections.

Composite Name	Fiber Volume fraction	Ultimate Tensile strength (MPa)	Tensile modulus (GPa)
Vakka	0.374	66.02	1.80
Sisal	0.372	50.04	1.62
Banana	0.376	60.91	1.09
Bamboo	0.373	121.52	2.25

Table:1 Fiber Properties at Vf = 0.37

Composite Name	Fiber Volume fraction	Ultimate Flexural strength (MPa)	Flexural modulus (GPa)
Vakka	0.401	93.80	3.38
Sisal	0.407	98.5	2.52
Banana	0.405	91.7	2.07
Bamboo	0.409	127.5	3.68

Table:2 Fiber Properties at Vf = 0.40

The single fiber pullout test, the microbond test, the single fiber fragmentation test, and the micro-indentation test can all be used to determine the fiber interfacial strength. The force required to extract a single fiber axially from a single matrix can be used to calculate the shear strength of the fiber/matrix interface in a fiber-reinforced composite. The microbond pullout test, which consists of a modified single fiber pullout test, is thought to be a single filament embedded in the matrix. When the volume fraction level is maintained at 0.37, the tensile property of composites made of vakka fiber and other natural fibers is increased, according to a review of surveys of these properties are as shown in the Table.1. It has been observed that the increase in tensile properties with respect to volume fraction of vakka fiber composite are also more than those of sisal and banana composites and comparable to those of bamboo composites Fig.1. (K. Murali Mohan Rao et al, 2009) [15].

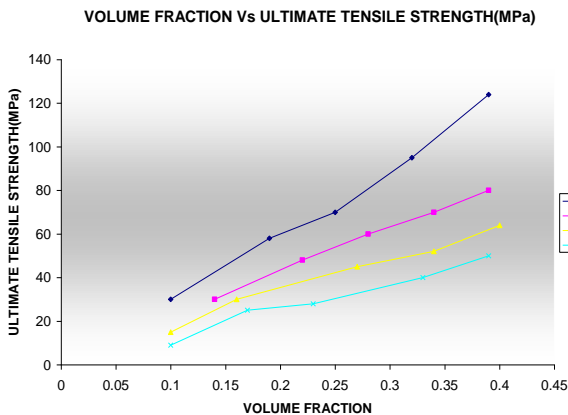


Fig:1 Volume Fraction Vs Ultimate Tensile Strength

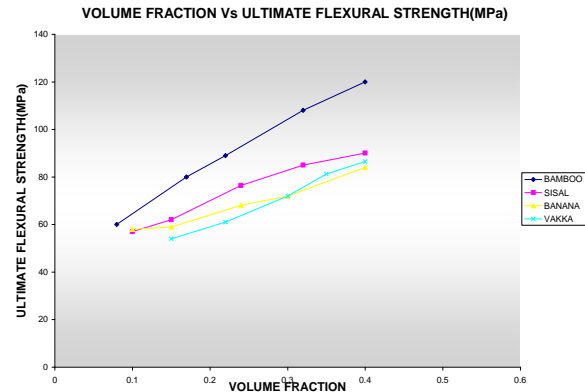


Fig:2 Volume Fraction Vs Ultimate Flexural Strength

While the flexural modulus of vakka fiber composite is significantly higher than that of banana and sisal fiber composites and also very close to bamboo fiber composites when maintaining the volume fraction at the same level of flexural strength, the flexural strength of vakka fiber composite is greater than that of banana composite and is closer to sisal fiber composite with respect to the volume fraction of 0.40. The dielectric strength of vakka fiber composite increases with increase in volume fraction of fiber in the composite unlike the case of sisal, bamboo and banana composites Fig.2. The dielectric strength being a unique feature of vakka fiber composite can be suggested for electrical insulation applications. Biodegradability is defined as the tendency of materials to suffer degradation by living organisms present in the natural environment (bacteria, fungi). The majority of commercial plastics are not directly

biodegradable but natural fibers are biodegradable, this was an added advantage when compared with commercial plastics the isocyanate adhesive was somewhat more resistant to fungal attack than the phenol-formaldehyde adhesive so that it can be used for exterior applications in construction field and automobile applications.

In order to join the FRP material and the vulcanized rubber, it is best to add a coupling agent with a polymer that can be mixed chemically onto the fibers. An adhesive similar to vulcanized rubber is applied with high frequency electrical heating until the exothermic reaction is sufficient to raise the temperature of the adhesive. (Maya Jacob and others, 2004) [11] Energy-absorbing materials composed of rubber, composites, or elastomers are frequently used in shock and vibration control devices. Because of their extremely high elongation or elastic deformation capabilities, rubber and elastomeric materials have a springy quality. Elastomeric materials, when subjected to a shock load, elastically deform to absorb stress and vibration. Viscoelastic qualities of some elastomers and gel materials can also have a damping effect.

CONCLUSION

Owing to its superior mechanical qualities in terms of aspect ratio, affordability, and environmental friendliness, natural fiber reinforced composites are gaining a lot of attention in research and could eventually replace commercial composites. It is possible to use natural fiber-reinforced polymers (NFRP) as an alternative to metal matrix composites because they are treated with a firm natural rubber adhesion that forms a strong interface between the matrix and the fiber, increasing tool life and providing a cushioning effect during machining.

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