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A REVIEW ON DEGRADABLE HYBRID NATURAL FIBRE POLYMER COMPOSITES

ALEX.S¹ · Dr.STANLY JOHNS RETNAM²

¹Assistant Professor,

Department of Mechanical Engineering, SNG College of Engineering, Ernakulum, Kerala, India

²Associate Professor,

Department of Mechanical Engineering, Noorul Islam college of Engineering, Kanyakumari, India

ABSTRACT

The natural fiber is more utilized for reinforcing polymer composites than using synthetic fiber nowadays. The natural fibers are more advantages related to their low-density, availability, biodegradability, low-cost, and non-abrasive processing characteristics when compared with synthetic fibers. However, these natural fibers are relatively poor moisture resistance, fiber wetting, and its adhesion to the matrix, which affecting mechanical properties. Then some structural modifications are necessary for improvements. A more efficient way to enhance properties of polymer composites is to produce a hybrid composite, so that their individual characteristics may be transferred to the final composite, originating a material with intermediate properties and with potential. This review paper explores the need of developing hybrid natural fiber (bamboo with steel) as reinforcement in biodegradable polylactic acid. This gives a new horizon to the use of related materials in various applications.

Keywords: Biodegradation, Hybridization, Natural Fibers, Synthetic Fibers, Tensile Modulus

I. INTRODUCTION

The term 'composite' in material science refers to a material made up of a matrix containing reinforcing agents. Reinforcement is the part of the composite that provides strength, stiffness, and the ability to carry a load. In manufacturing, fibers are the most commonly used reinforcement that yields Fiber Reinforced Composite (FRC). [1] The reinforcement is embedded into the matrix. Although the SFRPCs possess exclusive mechanical strength, they have got some serious drawbacks such as high cost, high density (as compared to polymers), and poor recycling and non biodegradable properties. For these reasons, over the last few years natural plant fibers reinforced polymer composites are increasingly gaining attention as viable alternative to SFRPCs. Natural fiber reinforced composites with thermoplastic matrices have successfully proven their qualities in various fields of application. The growing interest in using natural plant fibers as reinforcement of polymer-based composites is mainly due to their availability from renewable natural resources, satisfactorily high specific strength. The biodegradability of the natural plant fibers may present a healthy ecosystem while the low costs and good performance of these fibers are able to fulfill the economic interest of industry. But still the mechanical strength of a natural fibers reinforced polymer composite (NFRPC) could not match that of a SFRPC and the natural fibers would not replace synthetic fibers in all applications. Actually, natural fibers has gained attention as an alternative to synthetic fiber by using natural fibers as reinforcement in plastic to reduce cost, increase productivity and improve mechanical properties of product. However, the applications are limited due to its poor mechanical properties and high moisture absorption, compared to composites with synthetic fibers. So minimize these problems and to enlarge the possible applications, a more efficient way to enhance properties of these composites is

to combine distinct fibers, i.e., to produce a hybrid composite, so that their individual characteristics may be transferred to the final composite, originating a material with intermediate properties and with potential increase in the range of applications. A number of review papers have also appeared describing different aspects of NFRPCs. **Ramanpreet Singh *et al.*, 2014** “Investigation of Flexural behavior of hybrid natural fiber composite with recycled polymer matrix” studied the flexural behavior of hybrid natural fiber reinforced composite. In this work composites based on recycled high density polyethylene (RHDPE) and natural fibers were made. Their results showed that the maximum Flexural Strength and maximum Specific Flexural strength is obtained from the sample having 20% Sisal fiber + 5% hemp fiber as reinforcement with HDPE as a matrix. **Mohan Babu K *et al.*, 2013** “Fabrication and Analysis of Hybrid Polymer Green Composite” made an attempt to produce natural fibre made hybrid polymer composite. The hybrid polymer is made by mixing Cashew Nut Shell liquid with General Purpose resin in different proportions. It was concluded that strength of the composite is compromised at the cost of bio-degradation. **P Sivaraj *et al.*, 2014** “Prediction of Mechanical Properties of Hybrid Fiber Reinforced Polymer Composites” made a systematic approach to evaluate and study the effect of process parameters on tensile flexural and impact strength of coir and bagasse fiber reinforced polyester-based hybrid composites and also predicts the properties of random oriented hybrid composites. **Dr A Thimmana Gouda *et al.*, 2014** “A Wear Study on Hybrid Natural Fiber Polymer Composite Materials Used As Orthopaedic Implants” were constituted the wear study of 2%, 24% and 36% of Hybrid Fiber (Natural fiber- Sisal, Jute and Hemp) polymer composite material used as Bio-material. It is found that appreciable improvements in tribological properties of the 36% Hybrid Natural fiber polymer composite material when compared with 12% and 24% Hybrid Natural fiber polymer composite material. This study suggests 36% Hybrid Natural fiber polymer composite material can be used for different applications in the human body bone replacement or orthopedic implant. **Mayur Thombre *et al.*, 2014** “Study of mechanical properties of hybrid natural fiber composite” studied the mechanical behavior of hybrid natural fiber composites. Here the samples of several Jute-Bagasse-Epoxy & Jute-Lantana camara-Epoxy hybrids were manufactured using hand layup method and the weight fraction of fibre and matrix was kept at 40%-60%. So it has been found that they also have higher tensile strength than glass, good elasticity, excellent resilience and in turn it would not induce a serious environmental problem like in glass fibers. **K. Mumtazeh Siddique *et al.*, 2014** “Effects of Fiber Length and Fiber Ratio on the Biodegradability of Jute Polymer Composites”. Their studies focus on the fabrication of jute polymer composites, effects of fiber length and fiber ratio on the biodegradability of jute polymer composites and biodegradation. Weight loss of the composites revealed that composites are polymers didn't lose their weight. **Soma Dalbehera S. *et al.*, 2014** “Study on mechanical properties of natural fiber reinforced woven jute-glass hybrid epoxy composites” In this investigation a new hybrid composite with epoxy as a resin and reinforcing both bio waste (jute) and traditional filler (glass) as a continuous layered mat composites were used by keeping the position of glass and jute fabric as (0°-90°) and (45°-45°) for all stacking sequences. The study on the effect of stacking sequence on tensile, flexural and inter laminar shear properties of untreated woven jute and glass fabric reinforced epoxy hybrid composite has been investigated experimentally. **U.S. Bongarde *et al.*, 2014** “Review on natural fiber reinforcement polymer composites” This research deals with a view of different natural fibers reinforced polymer composite with its manufacturing processes and characterization especially coir and jute fiber. Hybrid composites may replace or reduce utilization of synthetic fibers in application of automotive, building industries, aircraft. **R. Sakthivel *et al.*, 2014** “Experimental Investigation and Analysis of Mechanical Properties of Hybrid Polymer Composite Plates”. In the project natural fiber and glass hybrid composites were fabricated by using epoxy resin combination of hand lay-up method and cold press method. A significant improvement in tensile strength was indicated by the woven fiber glass hybrid composites. In this hybrid composite laminates banana-glass-banana (BGB) and glass-banana-glass (GBG) exhibit higher mechanical properties due to chemical treatment to natural fibers. The tensile strength and flexural strength increases with increasing fibre volume fraction.

II. HYBRID FIBRE COMPOSITES

Hybrid composites [2] are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber. The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies. Hybrid composites include multiple reinforcing such as natural as well as synthetic fiber. Hybrid composites may replace or reduce utilization of synthetic fibers in application of automotive, building industries, aircraft. The properties of a hybrid composite mainly depend upon the fibre content, length of individual fibres, orientation, extent of intermingling of fibres, fibre to matrix bonding and arrangement of both the fibres.

Figure 1: The three main hybrid configurations: (a) interlayer or layer-by-layer, (b) intralayer or yarn by-yarn, and (c) intra yarn or fiber-by-fiber

1. In the interlayer configuration, the layers of two fibre types are stacked onto each other. This is the simplest and cheapest method for producing a hybrid composite. In the intralayer hybrid, the two fiber types are mixed within the layers. This is illustrated in Fig. 1b, where different yarns are co-woven into a fabric. Other intralayer configurations such as parallel bundles are also possible. The two fiber types can also be mixed or co-mingled on the fiber level, resulting in an intra yarn hybrid (see Fig. 1c). More complex configurations can be obtained by combining two of these three configurations. For example, an intra yarn hybrid can be woven together with a homogeneous.

III. BIODEGRADABLE COMPOSITES

Biodegradation is the chemical termination of materials. It is nature's way of recycling wastes, or breaking down organic matter into nutrients that can be used by other organisms. Degradation is carried out by a huge assortment of bacteria, fungi, insects, worms, and other organisms that eat material and recycle it into new forms. Bio-based and biodegradable products have raised great interest in the recent years since the growing concern for the environment and substitute traditional, non-biodegradable polymers. Biopolymers offer environmental benefits such as biodegradability, greenhouse gas emissions, and renewability of the base material. The majority of biodegradable polymers are not widely used because they are too expensive and the range of the material selection suitable for various endue products is limited.

IV. HYBRID FIBRE BIODEGRADABLE COMPOSITES

Hybrid bicomposites consists of a biodegradable naturalfibers with synthetic fibers along with a matrix. The natural to natural fibre hybridization has good biodegradability but its resistance is less than that of synthetic fibre. The properties of a hybrid composite depend on the fiber content, fiber length, orientation of fiber, extent of intermingling of fibers, fiber to matrix interface, layering pattern of both fibers and also dependent on the failure strain of individual fibres.

4.1. Biofiber-Synthetic Fiber Hybrid Composite

Hybrid biocomposites can be designed by the combination of a synthetic fibre and natural fibre (biofibre) in a matrix and a combination of two natural fibre / biofibre in a matrix. Hybridization with glass fibre provides a method to improve the mechanical properties of natural fibre composites and its effect in different modes of stress depends on the design and construction of the composites. In general, composite containing 10% EFB/10% glass fiber gave an optimum tensile and impact strength for treated and untreated hybrid composites. Tensile properties were found to increase with addition of coupling agent. Material characterization showed improved stiffness, strength, and moisture-absorption stability, while flexural tests on laboratory-scale plates demonstrated enhanced structural behavior. These hybrid cellular biofibre-based composites were found to provide an economic and environmentally friendlier alternative to entry-level synthetic composites.. The fibres play an important role in the impact resistance of the composites as they interact with the crack formation in the matrix and act as stress transferring medium. Hybridization with a synthetic fiber also has a profound effect on the water absorption property of composites. The water uptake of hybrid composites was found to be less than that of unhybridized composites. Mechanical properties of the composites were found to increase with increase in the amount of glass fiber in the hybrid. Hybrid composites containing more of waste fiber showed good reinforcement effect than the composites reinforced with more of glass fiber. The hybrid blends of natural and synthetic fibers were fabricated and found to significantly improve the characteristics of biocomposites with minimal cost and environmental impact. The bio composites have adequate short-term performance and that they can efficiently compete with housing

panels made from conventional structural materials. Hybridisation of natural fibre with glass fibre was found to increase heat transport ability of the composite

4.2. Biofiber- Biofiber Hybrid Composite

Another innovative approach to hybrid composites is the incorporation of two natural fibres in a matrix system.. A positive hybrid effect was observed in the flexural strength and flexural modulus of the hybrid composites. The hybrid biocomposites from natural fibers were fabricated by a novel high volume processing technique named 'biocomposite sheet molding compound panel' (BCSMCP) manufacturing process.

V. NATURAL- METALLIC FIBRE HYBRID COMPOSITE

The recent area of research is concentrated on degradable hybrid of natural- metallic fibre composites, which are blended with resins. The natural fiber composites are seen as potential materials for many engineering applications. The bamboo, steel and polylactic acids are discussed in details as follows:

5.1 Bamboo fiber reinforced composites

Bamboo plants are giant, fast-growing grasses that have woody stems. The characteristics of each vary in size, growth habit, sun tolerance, soil moisture needs and heat/ cold temperature tolerance. [3] Several investigators have examined bamboo as a source of best fiber and as a source of cellulose from pulping the bamboo. Bamboo fibers are often known as natural glass fiber due to its high strength with respect to its weight derives from fibers longitudinally aligned in its body. The tensile strength of bamboo is relatively high and this makes bamboo an attractive alternative to steel in tensile loading application. Instead of their superior properties, the application of bamboo fibers in polymer composites is very much limited due to its hydrophilic nature which hinders the bonding with the hydro- phobic polymers. Hence, in the recent times, many researchers have worked to modify the bamboo finer surface. Alkali (NaOH) treatment [3] (mercerization) is one of the commonly used techniques for extracting and surface modification of the bamboo fibers.

Proprieties	Bamboo fibre	Glass Fibre
Density	Low	High
Cost	Low	High
Biodegradability	High	Low
Recyclability	High	Low
Renewability	High	Low
Energy Extraction	Low	Low
CO ₂ Absorbtion	High	Low

5.2 Steel Fibers

The ductile steel fibres delivered composites with a high stiffness and a high strain-to-failure. The strain-to-failure can be up to 22%, which is much higher than a typical carbon and glass fiber composite (10 and 5 times, respectively). Steel fibre composites with ductile matrices showed the highest strain-to-failure and distinctly different failure behaviour, compared to a steel fiber composite with a brittle matrix. In both cases the strain-to-failure could be further improved using a saline treatment which increased the adhesion strength. By replacing low amounts of steel fibers by carbon or glass fibers, the composite strength increased, but with a significantly lower strain-to-failure. However, the sudden failure which is typical for carbon and glass fiber composites was not present. Adding steel fibers to self-reinforced polymers increased its stiffness and, also its specific stiffness despite the high density of steel. In contrast to hybridization with a brittle fiber, no loss in strain-to-failure in a tensile test was measured. For several years the interest has grown in the use of steel fibers as reinforcement for structural composites with polymer matrix. However, steel fibers have a unique feature compared to traditional reinforcing fibers (glass, carbon): they combine high stiffness with a (potentially) high elongation at break. This is even more interesting since very fine steel fibers (diameter of <10 micron) become available. The purpose of this research is to identify the key factors that determine the mechanical properties of steel fiber reinforced polymer composites, and to optimize these properties.

5.3 Polylactic acid as a biodegradable reinforcement for Natural fibre

Polylactic acid is [4] versatile polymer made from renewable agricultural raw materials, which are fermented to lactic acid. The polylactide is fully biodegradable. The biodegradation occurs by hydrolysis to lactic acid, which is metabolized by micro organisms to water and carbon

monoxide. By composting with together with other biomass the biodegradation occurs within two weeks and the material has fully disappeared within 3-4 weeks. PLA has better mechanical properties compared to other polymers. Plastic bags for household bio waste, barriers for sanitary products and diapers, planting cups, disposable cups and plates are some typical applications of PLA. Poly (lactic acid) (PLA) is a biodegradable polymer with biocompatibility and mechanical properties and can be machined easily.[5] PLA has been used in orthopaedic treatments. In the body, PLA degrades into lactic acids, which is one of the metabolites in the body, and water. Many biomaterials in the form of fibers have been developed and used in much biomedical application, such as wound dressing and bone scaffold. So PLA if combined with hybrid fibre of steel and bamboo its degradability should be increased.

Proprieties	PLA composite	PP Composite
Flexure Modulus(GPa)	3.4	1.6
Tensile strength(MPa)	60	30
Biodegradability	High	Low
Density(g/cm ³)	1.26	0.9
Elongation to break (%)	8	-

The hybrid composite strength is about 50% better compared to similar PP/flax fiber composites, which are used today in many industrial applications.

VI. CONCLUSION

The present review focuses on the progress of degradable natural-metallic fiber reinforced composites. Now a day's research is going on development of bio-composites to replace synthetic composite materials. The combination of different natural fibers found to give better mechanical and physical properties. Several limitations must be overcome in order to exploit the full potential of natural fibers. At first proper fiber surface treatment should be developed and implemented. Secondly properties of composites are greatly depended on the volume percentages of fibers and resin. The current challenge is to make the biocomposite so that the toxicity to the atmosphere can be reduced. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry.

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