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Hybrid Bamboo and Glass Fiber Polymer Composite – A Review

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Abstract *— **Hybrid composites are advance conceptual composite materials. These are composite materials are the material which contains two or more different types of natural/synthetic fiber in which one type of fiber could neutralize with what are lacking in the other. Hybridization of natural fibers is stronger and high corrosion resistance than synthetic fibers like glass can improve the various mechanical and chemical useful properties. This paper makes an attempt to set a review on hybrid polymer composites reinforced with glass and bamboo fiber based on their biodegradability. The importance of biodegradability is to develop composite materials which are ecofriendly***

Keywords *— **Biodegradation, Hybridization, Natural fibers, Synthetic fibers, Tensile modulus***

I. INTRODUCTION

The Natural fiber composites having more environmental advantages such as lower pollutant emissions, lower green house gas emissions and end of life biodegradability of components. From recent studies comparing the [1] environmental performance of natural fiber composites with glass fiber reinforced composites and found that the natural fiber composites are environmentally superior over its specific applications. The Natural Fiber composites are likely to be environmentally superior to Glass fiber composites in most applications due to lower environmental impacts and have higher fiber content for equivalent performance, by which reduces the amount of more polluting base polymers. There for Also its lower weight improves fuel efficiency and reduces emissions during the use phase of the component, especially in auto applications. The biodegradability of natural fibers results in energy and carbon credits.

II. IMPORTANCE OF BAMBOO FIBER

Bamboo in comparison with other natural fibres is ecofriendly with high growth rate and fixing the carbon dioxide to atmosphere, which makes it the most important plant fibres. Bamboo has several advantages over other fibers due to light weight, high strength, stiffness, biodegradability, and even its roots and leaves keep the soil together and protect it against the sun respectively. Because of these properties bamboo can be used traditionally for manufacturing of living utilities. Bamboo can also be used as reinforced composite materials base on extracting appropriate fibers in proper manner. Bamboo is the last sustainable plant resource that has not been vastly used. Many natural fibers have been studied as reinforcements for both synthetic polymers and biopolymers. The Plant fibers comprised of cellulose fibrils dispersed in a matripilx of lignin and hemicelluloses. They also contain small amounts of free carbohydrates, proteins, extractives, and inorganics. Cellulose is the primary structural component of plant fibers and the most abundant naturally-occurring polymer on earth. Hemicelluloses are polysaccharide polymers comprised of shorter polymer chains than cellulose. Lignin is an amorphous polymer of phenol-propane units. It can be a trusting agent that gives plant cell walls their rigidity. Bamboo fibers contain more lignin than many other natural fibers, which can make them brittle.

III.COMPARISON OF BAMBOO AND GLASS FIBER

The bamboo is also called natural glass fiber because of its strength. The remarkable properties of bamboo fibers such as low density and specific strength and stiffness can be compared with glass fibers. The hybrid composites treated with alkali bamboo fibers were possess higher flexural properties. The surface changes in bamboo fiber will effectively removing the impurities and bond between fibers in which the various compositions classified in the different percentage will get the different results of testing. This is due to the hydrophilic nature of bamboo fiber, where the different methods required for improving interfacial surface adhesion.

This means that by understanding the fiber structures and characteristics that influence to composite performance, it could lead to the development of additives, coating, binders, or sizing of the natural fiber and a variety of polymeric matrices. When specific modulus of lignocelluloses fibers is considered, the lingo cellulosic fibers show values that are comparable to or even better than glass fibers.

TABLE I - COMPARISON OF BAMBOO AND GLASS FIBER

PROPERTY	BAMBOO	GLASS FIBER
DENSITY	LOW	HIGHER THAN BAMBOO GLASS FIBER
COST	LOW	HIGHER THAN BAMBOO GLASS FIBER
DISPOSAL	BIODEGRADABLE	NON-BIODEGRADABLE
CO_2 ABSORPTION	YES	NO
RECYCLABILITY	YES	NO
RENEWABILITY	YES	NO
ENERGY FOR EXTRACTION	LOW	HIGH

IV. HYBRID COMPOSITE

In the case of polymer composites, hybrid composites are these systems in which one kind of reinforcing material is incorporated in a mixture of different matrices or two or more reinforcing and filling materials are present in a single matrix or both approaches are combined. The incorporation of two or more lingo cellulosic fibres into a single matrix has led to development of hybrid composites. The behavior of hybrid composites is a weighed sum of the individual components in which there is more favorable balance between the inherent advantages and disadvantages. While using a hybrid composite that contain two or more types of fiber, the advantages of one type of fiber could complement with what are lacking in the other. As a consequence, a balance in cost and performance could be achieved through proper material design. The strength of the hybrid composites is dependent on the properties of fiber, the aspect ratio of fiber content, length of individual fiber, orientation of fiber, extent of intermingling of fibres, fibre to matrix interface bonding and arrangement of both the fibers and also on failure strain of individual fibers. Maximum hybrid results are obtained when the fibers are highly strain compatible. R.Sakthivela and D.Rajendran (Experimental Investigation and Analysis a Mechanical Properties of Hybrid Polymer Composite Plates, 2014). In this 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.

A. BAMBOO/GLASS FIBER HYBRID

In spite of several merits, natural fibers show lower modulus, lower strength and poor resistance when compared with the composites reinforced with synthetic fibers such as glass, carbon and aramid. These limitations can be reduced by introducing hybrid composites where in two or more fibers are reinforced to a single matrix. The interlinking of of Bamboo with glass fibers produces an advanced composite which have the properties like low weight, good mechanical properties and tribological properties. Due to the low density, the natural fibers are widely used as reinforcing agent as it is high biodegradability.

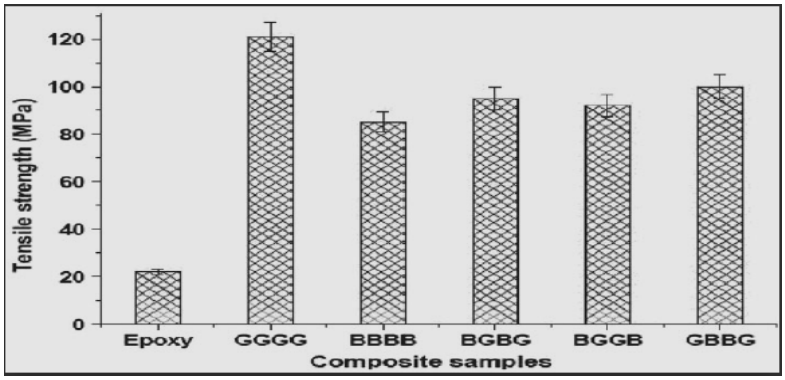

Fig 1: Tensile Strength comparision of bamboo glass hybrid composite

B. BAMBOO HYBRID BIOCOMPOSITE

Recently, bamboo fibers is making attention to be hybridized with more corrosion-resistant synthetic fibers such as glass and carbon fibers in order to tailor the composites properties according to the desired structure under consideration. Since synthetic fibers degrade at a much slower rate or does not degrade at all, inclusion with natural fibres may lead to green environmental balances with improvement in performances. Hybrid bamboo-glass fibers composites exhibit improvements

in terms of stiffness, strength and moisture resistance properties. But the durability of bamboo-glass fibres composites under environmental aging was improved compared to pure composites. Capability of bamboo to produce seven types of shapes encompasses silver, stripes, laths, veneer, particles, strands until bamboo fibers gives a huge impact in creating valuable hybrid biocomposites based on bamboo for various applications. The hybrid approach glass fibre with bamboo fibre is an effective way to improve the strength and durability of bamboo. But it becomes ecofriendly by its biodegradation when it is added with proper biodegradable polymer. The common matrix added to bamboo glass fibre is polyester, polypropylene, Epoxy resin and vinyl ester.

V. BIODEGRADABILITY OF POLYMERS

This may be defined as degradable plastics as those which undergo a significant change in chemical structure under specific environmental conditions. [2] The changes results in a loss of physical and mechanical properties, as measured by LCA (Life cycle Assessment). Biodegradable plastics undergo degradation due to the action of naturally occurring microorganisms such as bacteria, fungi, and algae. Conventional plastics are resistant to biodegradation, as the surfaces in contact with the soil in which they are disposed are characteristically smooth. Microorganisms within the soil are unable to consume a portion of the plastic, which would, [3] in turn, cause a more rapid breakdown of the supporting matrix. The polymer matrix is derived from natural fiber reinforcements are biodegradable. Microorganisms are able to consume these materials in their entirety, eventually leaving carbon dioxide and water as by-products. When examining polymer materials from the scientific point of view, there are certain ingredients that must be present in order for biodegradation to occur. Most importantly, the active microorganisms (fungi, bacteria, actinomycetes, etc.) must be present in the disposal site. The organism type determines the appropriate degradation temperature, which usually falls between 20 to 60oC. Biodegradation of materials occurs in various steps. Initially, the digestible macromolecules, which join to form a chain, experience a direct enzymatic scission. This is followed by metabolism of the split portions, leading to a progressive enzymatic dissimilation of the macromolecule from the chain ends. Oxidative cleavage of the macromolecules may occur instead, leading to metabolization of the fragments. Either way, eventually the chain fragments become short enough to be converted by microorganisms. Ideally, the biopolymer will be disposed in a bio waste collection, and later composted. This process will ultimately leave behind carbon dioxide and water, which are environmentally friendly byproducts.

A. BIODEGRADABILITY OF HYBRID COMPOSITE

Biodegradation of a polymeric material is chemical degradation brought by the action of naturally occurring microorganisms such as bacteria and fungi via enzymatic action into metabolic products of microorganisms. It is the chemical dissolution or breakdown of materials. It occurs because of enzymatic action and involves living micro and macro organisms. Molecular degradation is activated by enzymes and can occur under aerobic and anaerobic conditions, leading to complete or partial removal from the environment. Linear polymers are generally more biodegradable than branched polymers. The biodegradability of natural polymer composite has been examined in various environments such as in the soil, compost and weather. The biodegradable natural fiber polymer composite could be used as an alternative to the synthetic fiber polymer composites. These polymers composite being biodegradable can be disposed in safe and ecologically sound manner, through disposal processes like putting compost, soil application, and biological waste water treatment. Based on its importance the research the application of biodegradable natural fiber in polymers reinforced composites is going on day by day. In order to prove the nature of its biodegradability the bio-composites were technically buried in garbage dump land, which consists of cellulolytic bacteria.

B. BAMBOO/ GLASS POLYPROPYLENE HYBRID COMPOSITES

Bamboo/glass polypropylene Hybrid composites of polypropylene reinforced with bamboo and glass fibers (BGRP) were fabricated using an intermeshing counter rotating twin screw extruder followed by injection molding. The effect of hybridization makes efficient fiber matrix interfacial adhesion. The storage modulus is higher for PP based bamboo/ glass fiber. The biodegradability [4] test progressed over time up to 700 days, the hybrid composites biodegradability enhanced with increasing RH content because the cellulose is easily attacked by microorganisms. The observations show that for PP/EG/natural fibre hybrid composites, with treatment, it shows better biodegradability rate. This is due to good interactions between molecular structure of matrix, fibers and NaOH in each case. The results suggested that it is possible to blend the non-degradable Polypropylene polymer and E-glass synthetic fiber with any natural fibre in order to improve its biodegradability. Bamboo could be utilized as biodegradable filler at end of use in polymeric composite materials to minimize environmental pollution rather than produce strong reinforcing fillers.

C. PLA AS A BIODEGRADABLE POLYMER

Poly lactic acid (PLA) is one of the most common biodegradable plastics for food packaging applications, which is the largest volume of plastic materials consumption. According to the discoveries by the previous studies revealed that anti-microbial properties as well as the biodegradation process of materials were influenced by the biodegradable reinforcing fibers. There are many different polymers from renewable sources poly lactic acid (PLA), cellulose esters, poly (hydroxyl butyrates), starch and lignin based polymer materials. Among them PLA has given high priority among other biodegradable polymers. This is linear aliphatic thermoplastic polyester, produced from renewable resources with good biocompatibility, non-toxic byproduct and high strength and modulus.

One of the [5] methods to improve the mechanical and thermal properties of PLA is the addition of fibers or filler materials. PLA/plant fiber green composites were widely investigated and it has been found that they exhibit increased fiber reinforcement. It is often observed that the increase in fiber loading leads to an increase [6] in tensile properties.PLA can be synthesized by the polymerization of D- or L-lactic acid or ring-opening polymerization of the corresponding lactide. Under specific environmental conditions, PLA can degrade to carbon dioxide, water and methane over a period of several months to two years, a distinct advantage compared to other petroleum plastics that need much longer periods. The final properties of PLA strictly depend on its molecular weight and crystallinity. In short PLA resins [7] are nowadays marketed for different applications.

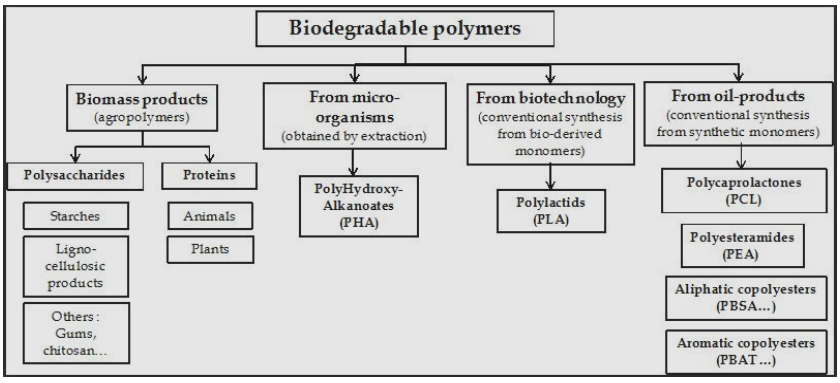

Fig 2: Classification of Biodegredable Polymer

D. BAMBOO FIBER/PLA BIO-COMPOSITES

In the preparation of Bamboo/PLA, bamboo fiber is treated with silane, then the composites can be prepared by melt blending and compression molding. Okubo [9] developed hybrid bio-composites based upon a biodegradable (PLA) matrix reinforced with microfibrillated cellulose and bamboo fiber bundles. [10].They found that by adding just 1 wt% of MFC with a high degree of dispersion an increase in fracture energy of nearly 200% was obtained. Lee prepared bamboo fiber-filled (PLA) eco-composites by mechano-chemical compositing with bamboo fiber (BF)- esterified maleic anhydride in the presence of dicumyl peroxide as a radical initiator.

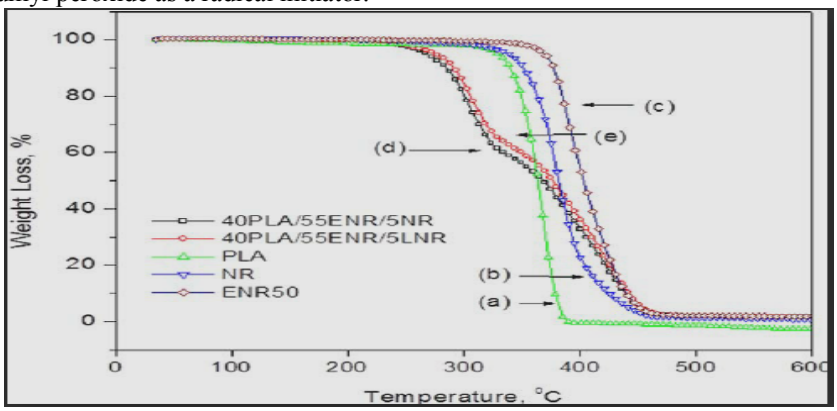

Fig 3: Comparision of weight loss % and temperature of PLA and other composite

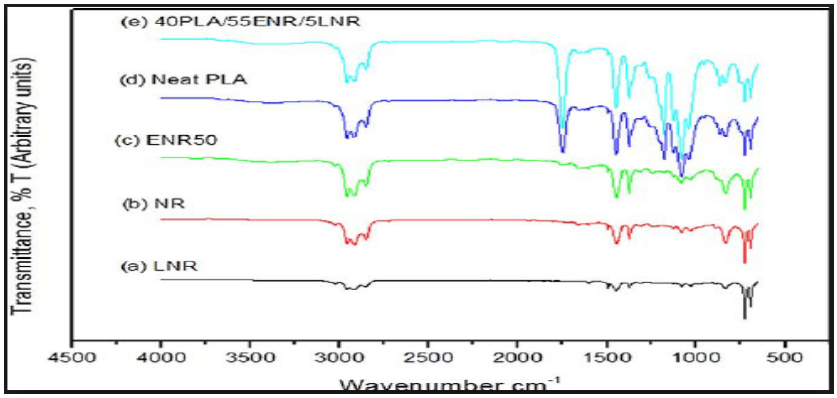

Fig 4: Comparision of Transmittance % and wave number of PLA and other composite

VI. CONCLUSION

Natural fibers reinforced PLA composites are a fully renewable materials with an effective degradability as compared to non renewable petroleum based products. Both PLA and natural fibers are hydrophilic in nature and is assumed that this property will facilitate a better adhesion. In this review attempts are made to search the possibility of developing a hybrid biodegradable polymer made of bamboo/glass along with polylattic acid. This can be applied to various fields such as household items, automobiles and food packaging systems. By using this type of polymers an ecofriendly atmosphere can be created and thus hazardous effects can be reduced

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