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Natural Fibre Reinforcement and Application in Polymer Composites – A Review

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Abstract: World moves from stone era to métal era and now moving towards composite era. Petroleum based synthetic fibre reinforced composite are more adoptable in day to day application due to properties that can replace metal. The drawback of synthetic fibre reinforced composite is it's renewability, degradibilty. The ecofriendly alternative to synthetic fibre is Natural fibre. Natural fibres are a promising reinforcement for use in composites on account of its low cost, low density, high specific strength and modulus, no health risk, easy availability in some countries and renewability. In recent years, there has been an increasing interest in finding new applications for natural-fibre-reinforced composites that are traditionally used for making ropes, mats, carpets, fancy articles and others. This review presents a summary of recent developments of natural fibre and its composites.

Keywords: Natural Fibres, Composites, Sisal, Rice husk, bamboo, jute.

I. INTRODUCTION

Composite materials are being widely used in recent period for day to day applications and at the same time they possess a vital role in manufacturing of highly sophisticated machines and equipment also. Composite materials has many advantages over the conventional materials such as light weight, simple and cheap manufacturing process and also have comparable properties of their constituent materials. So the main tasks for researchers are to improve the properties of composite materials according to the application and make them more durable, weightless and cost effective. Composites consists of two phases one is called discrete phase called reinforcing material, which may be fibre, particulate or flakes and the other is a continuous phase which termed as matrix material which possess the major share of composite material. In a composite material components like matrix and fibres are bounded together but its main difference from an alloy is that its constituents will retain their own identity and properties.

If we define composite materials, it is a unique combination of fibre and matrix where function of the fibre is to withstand load and make the composite stiffer meanwhile matrix is a binder which holds the fibre in place. Composite shows advantages like low weight, low density, low cost and good specific properties like tensile, flexural and impact strengths. It may possess applications in area where weight of the total equipment is a major problem, like rocket technology, aircraft industry, marine structures etc. By combining with some insulating material, composites can also utilized as thermal and electrical insulating material. Composites are used to prepare many mechanical components like brakes, drive shafts, flywheels, pressure vessels etc.

II. LITERATURE REVIEW

Gupta and Srivastava [1] had done a comparative study between unidirectional and mat form of Sisal fibre reinforced epoxy composite. This work investigated the tensile and flexural properties of sisal fibre reinforced epoxy composite. The composites were prepared by using hand lay-up method with 15, 20, 25 and 30 wt % of sisal fibres into epoxy matrix. It was found that the tensile and flexural properties of 30 wt% was maximum in unidirectional form than 15, 20 and 25 wt% as well as 30 wt% mat form.

Prabhakar et. al, [2] had studied mechanical and thermal properties of peanut shell powder reinforced epoxy composite. Alkali treatment has done with peanut shell powder with the concentrations of 2, 5 and 7 w/v% and the composites fabricated by varying the weight fractions of filler in the range of 5, 10 and 15 wt%. The effects of bio-filler content of the composites on tensile and thermal properties were evaluated by Fourier transmission infrared spectroscopy (FTIR), universal testing machine, scanning electron microscope (SEM) and thermal gravimetric analysis (TGA). The experimental results show that it is possible to produce composites using PSP as reinforcement. The addition of PSP (15 wt% of 7% alkali treated) improved the mechanical and thermal properties. Since many countries producing groundnut, the use of its wastes such as shell for producing useful components would be very attractive for the economy.

Arthanarieswaran et. al, [3] had studied the mechanical properties of banana and sisal fibre reinforced epoxy composites. In this experiment the effect of glass fibre hybridization was analysed. The different kinds of laminates were prepared in different stacking sequence.

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All the laminates were tested for tensile strength, flexural strength and impact strength. The micro structural behavior of the tested specimen was studied with the help of Scanning Electron Microscope (SEM). Tensile strength of composite increases with increase in glass fibre layers, where as banana-sisal fibre with two layers of glass fibres has higher flexural strength and laminate with sisal and three glass ply has better impact strength. It was observed that the hybrid composite laminates were showing moderate performance than the glass fibre composites. Hence it is suitable for the medium load applications such as welding helmet, chair, table, roof, and automobile body panels.

Braga and Magalhaes [4] had analysed mechanical and thermal properties of jute and glass fibre reinforced epoxy hybrid composite. The samples were tested according to ASTM standards. It was observed that for 18% jute fibre and 19% glass fibre in mass composite had better tensile properties compared to 31% jute fibre and 0% glass fibre in mass combination as well as 25% jute fibre and 7% glass fibre in mass combination. The flexural strength, impact energy and density increases with increase in jute fibre and glass fibre in epoxy, but decreases the loss mass in function of temperature and the water absorption. Fracture behavior and fibre pull-out of the samples were studied with the help of scanning electron microscope.

Shibata et. al, [5] had investigated the tribological behavior of rice husk ceramics made from rice husk sliding against stainless steel, alumina, silicon carbide and silicon nitride. High hardness of rice husk ceramics was obtained from the polymorphic crystallinity of silica. Friction tests were conducted using a ball-on-disk-type friction tester under dry conditions. High carbon martensitic stainless steel, Al_2O_3, SiC and Si_3N_4 were used as ball specimens. It was observed that the RH ceramics carbonized at 1400 ºC sliding against stainless steel balls showed extremely low friction coefficients (< 0.10) at low-contact pressures under dry conditions. For Si_3N_4 material the friction coefficients were extremely low for all tested condition of rice husk ceramics. Due to good compatibility of steel with carbon, the transfer film easily forms from rice husk ceramics on stainless steel balls. This transfer film behaves like a self lubricating film and hence the friction coefficient was low. The specific wear rates of rice husk ceramics tended to decrease with increasing contact pressure and decreasing sliding velocity, irrespective of the counterpart material. Although Si_3N_4 balls induced the highest specific wear rates of rice husk ceramics among other materials.

Militky and jabbar [6] had done comparative study of fibre treatments on the creep behavior of jute epoxy composites. The short term creep behavior of novel treated jute fabric was analysed. The Jute fabric was treated with CO_2 pulsed infrared laser, ozone, enzyme and plasma. The composites were prepared by hand lay-up method followed by compression molding technique. The creep and dynamic mechanical tests were performed in three-point bending mode by dynamic mechanical analyzer (DMA). The creep strain was studied for untreated and treated composites. The treated composites showed less creep than the untreated composites at all temperatures. At higher temperatures the laser treated composites showed the best result in terms of creep deformation. The Burgers four parameters model was used to fit the experimental creep data using R statistical computing software. Experimental data and theoretical curves obtain were close to each other. The better interlocking of fibres and matrix at the interface was revealed for laser treated composites.

Verma et. al, [7] reviewed coir fibre reinforcement and application in polymer composites. In this work the focus on use of natural fibres for replacement of petroleum other non decaying materials based product. Investigation has been carried out to make use of coir; a natural fibre abundantly available in India. Tribological behavior of coir fibre, the mechanical properties and the effect of various fibre treatment on the mechanical properties were reviewed. This review focussed at providing knowledge to enhance further research in this area.

Biswas and Satapathy [8] have studied erosion characteristics of red mud filled bamboo–epoxy and glass–epoxy composites. Hand layup technique was used for composite fabrication. The roving bidirectional bamboo/glass mats were reinforced in red mud filled epoxy. The red mud used was in 0, 10 and 20 wt%. Mechanical test like micro-hardness, density, tensile, flexural, inter-laminar shear strength and impact tests were performed according to ASTM standards. The solid particle erosion experiments were carried out as per ASTM G76 on the erosion test rig. Taguchi method was used which provides a simple, efficient and systematic approach to determine optimal machining parameters. The mechanical properties like tensile strength, tensile modulus, flexural strength, impact strength and inter-laminar shear strength of composites with bamboo–fibre reinforcement are found to be much lower than glass–fibre reinforcement. The micro-hardness values of the bamboo fibre composites were relatively greater than the glass fibre composites. This suggests that bamboo fibre composites have the potential to replace glass in some applications that do not require very high load bearing capabilities. Hybrid composites suitable for applications in highly erosive environments can be prepared by reinforcement of bamboo fibres and filling of micro-sized red mud particles in epoxy resin. Possible use of these composites in components such as pipes carrying coal dust, helicopter fan blades, industrial fans, desert structures, low cost housing, etc. was recommended.

Rout and Satapathy [9] had studied mechanical and tribo performance rice husk filled glass epoxy composites. The composites were prepared by hand layup technique followed by light compression molding with composition of 5, 10 and 15 wt% of rice husk in glass fibre and epoxy. The composites were tested for density, microhardness, tensile strength, flexural and inter laminar shear, impact strength and erosion test according to ASTM standards. For tensile test ASTM D3039-76, flexural test ASTM D2344-84, impact test ASTM D256 and solid particle erosion test ASTM G76 were followed. In order to obtain minimum erosion rate, appropriate combination of operating parameters, techniques like artificial neural network (ANN) were studied to understand the interrelated effect of parameters on the wear process. The hardness, tensile modulus and impact energy of these new class hybrid composites are improving with rice husk filler addition while a steady decline of tensile and flexural properties were observed. The erosion wear performance of glass epoxy composites improves with the incorporation of particulate fillers. Among the three weight percentages of rice husk in the composite, 15 wt. % rice husk composites has shown maximum erosion resistance. Such hybrid composites possess fairly good potential for application in erosive situations like engineering structures in dusty environment and low cost building materials in deserts. These composites, in general may also be recommended for applications like partition boards, false ceilings, pipe lines carrying coal dust, light weight vehicles, etc.

Fernandes et. al, [10] had studied hybrid cork–polymer composites containing sisal fibre: Morphology, effect of the fibre treatment on the mechanical properties and tensile failure prediction. They investigated the use of short sisal fibre with and without polyethylene-graft-maleic anhydride (PE-g-MA) as a strategy to reinforce cork–polymer composite (CPC) materials. The use of alkali treatment of sisal to improve fibre–matrix adhesion was evaluated. High density polyethylene (HDPE) was used as matrix and the composites were produced in a two-step process using twin-screw extruder followed by compression moulding. FTIR, TGA and XRD were used to confirm the sisal fibre modification. Additionally, morphology, density, diameter and tensile properties of the fibres were evaluated before processing. The hybrid composites containing cork powder (40 wt. %) and randomly distributed sisal fibres were evaluated in terms of morphology and mechanical properties. The use of a 10 wt. % sisal fibre in the presence of a 2 wt. % coupling agent based on maleic anhydride has shown to improve the tensile and flexural properties of the composites. The higher mechanical properties were achieved by using alkali treated sisal fibres and PE-g-MA. In the presence of the coupling agent the composite morphology revealed good interfacial adhesion between the natural components and the polypropylene matrix, being in accordance with the mechanical results.

Jarukumjorn and Suppakarn [11] had investigated effect of glass fibre hybridization on properties of sisal fibre–polypropylene composites. Natural fibre reinforced polymer composites became more attractive due to their light weight, high specific strength, and environmental concern. However, some limitations such as low modulus, poor moisture resistance were reported. In this study it was conclude that Tensile, flexural, and impact properties of the sisal–PP composites were increased by adding the compatibilizer due to the improvement of interfacial adhesion between the fibre and matrix. Hybridization with glass fibre insignificantly enhanced the mechanical properties of the composites. Addition of glass fibre improved thermal stability of the PP composites. Thermal decomposition temperature of the composites increased with increasing glass fibre content. HDT of PP was considerably increased with adding sisal fibres and further improved by hybridization with glass fibres. However, incorporation of glass fibres into the sisal– PP composites was not notably changed the viscosity. Hybridization with glass fibres decreased water absorption of the sisal–PP composites.

Kaewkuk et. al [12] had studied effects of interfacial modification and fibre content on physical properties of sisal fibre/polypropylene composites. Sisal fibre (SF)/polypropylene (PP) composites were prepared at fibre content of 10, 20, and 30 wt. % and their mechanical, thermal, morphological, and water absorption properties were characterized. The interfacial modifications led to improved mechanical properties of the PP composites. Mechanical properties of the PP composites treated with alkalization and heat treatment were similar. This suggested that these techniques for fibre treatment were comparable. Adding MAPP provided the most effective enhancement in mechanical properties of the PP composites. With increasing fibre content, tensile strength and Young's modulus of the PP composites increased while elongation at break and impact strength decreased. SEM micrographs revealed that the interfacial modifications enhanced the interfacial adhesion between the fibre and the PP matrix. The interfacial modifications resulted in increased cellulose decomposition temperature of the PP composites. As fibre content increased cellulose decomposition temperature of the PP composites decreased. An increase in water absorption of the PP composites was observed with increasing fibre content. The interfacial modifications resulted in a reduction in water absorption of the PP composites. MAPP modified composite displayed the lowest water absorption.

Maurya et. al, [13] had studied the mechanical properties of epoxy composite using short sisal fibre. This work deals with the tensile, flexural and impact properties of the randomly oriented short sisal reinforced epoxy composite. The composites were prepared by hand lay-up method with various fibre length (5, 10, 15 and 20 mm)but constant 30 weight percent of sisal fibre content. The result offered that tensile strength was not increased by reinforcing sisal but flexural strength was improved 25% by 15 mm sisal fibre and large improvement was observed in impact properties by 20 mm sisal fibre.

Jearanaisilawong et. al, [14] had determined in plane elastic properties of rice husk composite from its morphology. In their study composite samples containing 5–20% mass fractions of rice husks were formed by compression moulding, and the orientation distributions of

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rice husks in the samples were evaluated from micrographs of the composite structure. Effective elastic properties of the composite were calculated from the Mori–Tanaka model that includes the effect of reinforcement orientation. The comparisons show that the proposed approach is adaptable to predict the in-plane anisotropic elastic properties of compression-moulded rice husk reinforced polypropylene composite.

Maples et. al, [15] had studied high performance carbon fibre reinforced epoxy composites with controllable stiffness. The mechanical properties of polystyrene-interleaved carbon fibre reinforced epoxy composites, which exhibit controllable stiffness, have been investigated. The flexural stiffness of the interleaved composites at room and elevated temperatures were predicted using simple beam theory and were found to be in good agreement with the measured values.

Li et. al, [16] carried out investigation to evaluate mechanical, thermal and friction properties of rice bran carbon/nitrile rubber composites by means of predicting the influence of particle size and loading. In their study four types of rice bran carbon (RBC) with different particle sizes were compounded with nitrile rubber (NBR) in a laboratory size two-roll miller were chosen. The obtained RBC/NBR composites were characterized using Field Emission Scanning Electron Microscopy (FE-SEM) and tensile tests. The overall results demonstrated that BC could act as ideal filler for NBR composites providing both economic and environmental advantages.

Guermazi et. al, [17] carried out investigations on the fabrication and the characterization of glass/epoxy, carbon/epoxy and hybrid composites used in the reinforcement and the repair of aeronautic structures. The mechanical properties of the carbon/epoxy composites, in the bulk material, were considerably higher than those of the glass/epoxy; the hybrid structure presented intermediate mechanical properties. The same trend was also observed in terms of wear properties. Finally, a deleterious effect on the strength of all composites due to hygrothermal exposure was established. However, carbon/epoxy composites seem to be less susceptible to aging damage after 90 days at 90°C.

III. APPLICATIONS

In this section we discuss the various applications of the hybrid reinforced composite materials and the various possibilities of the future scope that this material holds. The applications are varied and many because of the many advantages that composites have to offer.

3.1 USE OF COMPOSITE FOR THE DEVELOPMENT OF LEAF SPRINGS

Automobile world has an increased interest in reduction of weight by the replacement of steel by natural fibre reinforced composites. Moreover, the composite materials have more elastic strain energy storage capacity and high strength capacity and high strength to weight ratio compared to steel. Natural fibres are emerging as low cost, lightweight and apparently environmentally superior alternatives to glass fibres in composites.

Many industrial visits shows that steel leaf springs are manufactured by EN45, EN45A, 60Si7, EN47, 50Cr4V2,55SiCr7 and 50CrMoCV4 etc. These materials are widely used for production of the parabolic leaf springs and conventional multi leaf springs. Conventional (steel) leaf springs use excess of material making them considerably heavy.

Automobile manufacturers and parts makers have been attempting to reduce the weight of the vehicles in recent years. Emphasis of vehicles weight reduction in 1978 justified taking a new look at composite springs. This can be improved by introducing composite materials in place of steel in the conventional spring. Most commonly the conventional multi leaf springs are made of several steel plates of different lengths stacked together.

So when they are subjected to loading, due to the deflection of consecutive leaves, we can observe the friction between the two leaves. This friction will cause the fatigue failure of steel (conventional) leaf spring. For the above reasons, mono leaf composite spring will be a better option to replace the conventional steel multi leaf spring.

Figure 1: Leaf Spring

3.2 USE OF THE MATERIAL IN AUTOMOBILES AND AGV'S

Automobile world has an increased interest in reduction of weight by the replacement of steel by natural fibre reinforced composites. Moreover, the composite materials have more elastic strain energy storage capacity and high strength capacity and high strength to weight ratio compared to steel.

Natural fibres are emerging as low cost, lightweight and apparently environmentally superior alternatives to glass fibres in composites. In automotive applications, this material could be used in the manufacturing of the chassis and also the body of the automated guided vehicle and

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other hybrid cars being manufactured in the industry today. This material can also be used for the manufacture of inner coach compartments used in the railway system

The inner fenders and bumpers of the railway parts can also be manufactured using the present material.

Figure 2: Automatic Guided Vehicle (AGV)

In aircrafts too light weight requirements are given top priority and hence composites fulfil the necessary requirements and hence find extensive usage in the bodies of aircrafts as well.

Figure 3: Aeroplane

IV. REVIEW OBJECTIVES

The present review focuses on the progress of natural fibre in the development of composites, an effort to utilize the advantages offered by renewable resources for the development of bio composite materials.

It is a challenge to the creation of better materials for the improvement of quality of life with better mechanical properties.

V. CONCLUSION

The present review has been undertaken, with an objective to explore the potential of the natural fibre polymer composites and to study the mechanical properties of composites. The present review reports the use of natural fibres, as reinforcements in polymer matrix. This review focussed at providing knowledge to enhance further research in this area. The possibility of surface chemical modification of natural fibres have been extensively used in a wide variety of application, e.g., packaging, furniture etc.

The present contribution defines some selected works in the field of natural fibres. The influence of the source of natural fibre on the mechanical properties of bio composites was reported. Several natural fibre composites achieve the mechanical properties of glass fibre composites and they are already applied, e.g., in furniture industries etc. At present, the most important natural fibres are Sisal, rice husk, banana, jute, flax, bagasse and coir.

REFERENCES

[1] Gupta M. K and Srivastava R. K, “Tensile and flexural properties of sisal fibre reinforced epoxy composite: A comparison between unidirectional and mat form of fibres.” International Conference on Advances in Manufacturing and Materials Engineering, Procedia Materials Science 5(2014) 2434 – 2439, AMME 2014

[2] Prabhakar, Shah, Rao and Song, “Mechanical and thermal properties of epoxy composites reinforced with waste peanut shell powder as a bio-filler.” Fibres and Polymers (2015) 1119-1124

[3] Arthanarieswaran V. P and Kumaravel A, Kathirselvam M, “Evaluation of mechanical properties of banana and sisal fibre reinforced epoxy composites: Influence of glass fibre hybridization,” Materials and Design 64 (2014) 194–202

[4] Braga and Magalhaes, “Analysis of the mechanical and thermal properties of jute and glass fibre as reinforcement epoxy hybrid composites.” Materials Science and Engineering C 56 (2015) 269–273.

[5] Shibata, Yamaguchi and Hokkirigawa, “Tribological behavior of RH ceramics made from rice husk sliding against stainless steel, alumina, silicon carbide, and silicon nitride.” Tribology International 73 (2014) 187–194

[6] Militky and Jabbar, “Comparative evaluation of fibre treatments on the creep behaviour of jute/green epoxy composites.” Composites Part B 80 (2015) 361-368

[7] Verma, Gope, Shandilya, Gupta and Maheshwari, “Coir Fibre Reinforcement and Application in Polymer Composites: A review” Journal of Material and Enviromental Science, 4 (2) (2013) 263-276, ISSN: 2028-2508

[8] Biswas and Satapathy, “A comparative study on erosion characteristics of red mud filled bamboo–epoxy and glass–epoxy composites.” Materials and Design 31 (2010) 1752–1767

[9] Rout and Satapathy, “Study on mechanical and tribo-performance of rice-husk filled glass–epoxy hybrid composites.” Materials and Design 41 (2012) 131–141

[10] Fernandes, Mano and Reis, “Hybrid cork–polymer composites containing sisal fibre: Morphology, effect of the fibre treatment on the mechanical properties and tensile failure prediction”, Composite Structures 105 (2013) 153–162

[11] Kasama Jarukumjorn and Nitinat Suppakarn, “Effect of glass fibre hybridization on properties of sisal fibre–polypropylene composites,” Composites: Part B 40 (2009) 623–627

[12] Sulawan Kaewkuk, Wimonlak Sutapun and Kasama Jarukumjorn, “Effects of interfacial modification and fibre content on physical properties of sisal fibre/polypropylene composites,” Composites: Part B 45 (2013) 544–549

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ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 3, Issue 9, September 2016

[13] Mauryaa Hari Om, Guptaa M. K, Srivastavaa R. K and Singh H, "Study on the mechanical properties of epoxy composite using short sisal fibre," Materials Today: Proceedings 2 (2015) 1347 – 1355

[14] Jearanaisilawong, Eahkanong, Phungsara and Manonukul. "Determination of in-plane elastic properties of rice husk composite." Materials and Design 76 (2015) 55–63

[15] Maples, Wakefield, Robinson and Bismarck, "High performance carbon fibre reinforced epoxy composites with controllable stiffness." Composites Science and Technology 105 (2014) 134–143

[16] Li, M-C., Zhang, Y., Cho, U.R., Mechanical, Thermal and Friction Properties of Rice Bran Carbon/Nitrile Rubber Composites: Influence of Particle Size and Loading, Materials and Design (2014), doi: http: //dx.doi.org/ 10.1016/ j.matdes.2014.06.032

[17] Guermazi N, Haddar N, Elleuch K, Ayedi H. F, "Investigations on the fabrication and the characterization of glass/epoxy, carbon/epoxy and hybrid composites used in the reinforcement and the repair of aeronautic structures", Materials and Design (2013), doi: http://dx.doi.org/10.1016/j.matdes.2013.11.043

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