

Luffa Cylindrica and Coconut Coir as Reinforcement in Composites: A Review

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ABSTRACT: Exacerbating environmental problems, difficulty in waste disposal and extinction of petroleum reserves have resulted in exploration for environment friendly materials. Natural fibres are enjoying great attention in this regard. Researchers are curiously delving the usage of natural fibre as an alternative of synthetic fibres. Natural fibres offer biodegradability and lightness in weight. These materials are easily accessible and cheaper than their synthetic counterpart. The utilisation of natural fibres as reinforcement in composite materials is itself an effective waste management process. In this connection, an investigation has been carried out to collect information about luffa cylindrical and Coconut coir which are widely available in India. This review paper presents the current scenario of research status of luffa fibre and coconut coir. Many conclusions of the latest studies on properties, processing and application have been adduced in this review.

KEYWORDS: Natural fibres, biodegradability, Composite materials, Reinforcement, Luffa Cylindrica, Coconut coir.

I. INTRODUCTION

1. Composite: A composite material is a microscopic or macroscopic combination of two or more distinct materials which are not soluble in each other and having a recognizable interface between them. The combination of two or more materials rectifies weakness of one material by strength of other. The Composite material consists of two major component reinforcement and matrix. The main function of reinforcement is to carry load, provide toughness and prohibit crack propagation. On the other hand the function of matrix is to transmit the load to fibres and provide the craved shape by holding the reinforcement.

II. CLASSIFICATION OF COMPOSITE

2.1 Based on reinforcement

2.1.1. Particulate Composite.

Here reinforcement is of particle nature. The shape of the particles can be spherical, cubic or tetragonal. It can have irregular shape also. The particulate composite provides better stiffness as compare to fibrous composite. Particle fillers are generally used to enhance the surface hardness, electrical and thermal conductivity, abrasion resistance, decrease friction, improve wear, increase surface hardness, increase machinability and lower the shrinkage. The major limitation with particulate composite is that they have poor fracture resistance.

2.1.2. Fibrous Composite

Fibres are materials which have length greater than that of cross-sectional area. The reinforcement dimension greatly influences the characteristics of the composites. Fibres as a reinforcement depresses the growth and development of cracks due to long dimension which could otherwise lead to wreck, especially with brittle matrices. The fibrous material provides better fracture resistance.

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2.2. Based on Matrix Material

2.2.1. Polymer Matrix Composites

Polymers as matrix materials are synthetic plastics which can be processed easily. They possess lightness in weight and have desirable characteristics such as high chemical and thermal resistance, high strength etc. There can be two major classifications of polymers as thermosets and thermoplastics. The various thermoset polymers and their applications are epoxies, polyesters and vinyl esters used in aerospace, automotive, marine and chemical applications.

2.2.2. Metal Matrix Composites: A metal matrix composite provides higher specific modulus, higher specific strength, better properties at high temperatures and lower coefficient of thermal expansion. They are widely used in manufacturing of combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, structural members etc. Some of the metal matrixes are Aluminum and its alloys, titanium alloys, magnesium alloys, copper-based alloys, nickel-based super alloys and stainless steel which are suitable for high-temperature applications.

2.2.3 Ceramic Matrix Composites: Ceramic matrix composites own better toughness. These materials generally used to provide high temperature resistance. Popular ceramic matrixes are Aluminum oxide (Al_2O_3), silicon carbide (SiC) carbon etc.

3. Natural Fibre reinforced Composites:

The eco friendly and lower cost to synthetic fibre reinforced composite has led the researchers to explore use of natural fibres as reinforcement in the field of composites. The natural fibres are easily accessible and require low production cost. Researches are going on to collect information that up to what extent they can fulfil the desired specifications and properties for various uses. They are seen as a good renewable and biodegradable substitute to most of the synthetic fibre. Natural fibres can be further classified as plant fibres and animal fibres. Plant fibres such as Jute, kenaf, banana, sisal, coir have been examined as replacement of synthetic fibres.

4. Hybrid Composites

A composite which has two or more different types of fibres as reinforcement together in a common matrix is known as hybrid composite. (Bennet [13]) Not only fibres, in some cases, fibres with fillers in a common matrix is also said to be hybrid composite. Hybridization concept produces different range of properties as observed extensively by many research works. The material cost is reduced to a great extent and high performance is achieved by the effect of hybridization. Some of the combinations of fibres such as banana/sisal, glass/banana, glass/sisal, oil palm/sisal, glass/oil palm, pineapple/glass, and coir/glass, which produce better performance composites and plenty of research works have been carried out by earlier researchers using glass fibre. Natural fibres of various types are reinforced with synthetic fibres for producing a composite with high strength and low cost.

5. *Luffa Cylindrica*: *Luffa cylindrica* is a fruit which belongs to Cucurbitacea family. It is a very fast growing climber. The size of the luffa leaves are 7 - 20 cm across and it has three lobes. Luffa flower is bright yellow in colour. The fruits grow in the vascular cylinder shape. It has smooth covering and contains many seeds. The fruit is brown when mature and dries onto develop an inedible sponge-like structure. It is widely available in countries like India, Bangladesh, Sri Lanka, China, Vietnam. Chemical composition of the fruit is given below.

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Table 1: Chemical composition of Luffa Cylindrica (Wetaka and others [14])

Composition	Values
Cellulose	65.69%±3.77%.
Hemicelluloses	19%±3%.
Lignin	12.03%± 2.34%.
Moisture regain	10.81% ±1.34%.
Moisture content	9.74%±1.1%.

6. Coconut Coir: Coconut is a fruit of Arecaceae family. India is one of the largest producers of coconuts. Coconut owns versatility in usage ranging from food to cosmetics. The outer shell of the coconut is covered with fibrous husk which is known as coir. The word coir finds its origin from Dravidian word “*kayar*” which means cord. The white coir is extracted from unripe coconut whereas brown coir is extracted from matured coconut. Coir is widely used for making ropes, doormats, brushes, nets etc. The chemical composition of coir is shown below.

Table 2: Chemical composition of Coir (Verma and others [15])

Items	Percentages
Water Soluble	5.25%
Pectin and related compounds	3.00%
Hemi – cellulose	0.25%
Lignin	45.84%
Cellulose	43.44%
Ash	2.22%

III.LITERATURE SURVEY

Pannerdhass, Gnanavelbabu and Rajkumar et al. [1] in their research of hybrid composite consisting luffa and ground nut reinforced epoxy composite reported that composites having 40% treated fiber content exhibited higher values for the aforementioned properties than luffa groundnut fiber polymer composites with 30% and 50% fibre contents. The mechanical property values of luffa – groundnut reinforced composite were slightly higher than that of luffa fibre reinforced composite. The alkali treatment improved the adhesive characteristics of the surface of the luffa fibres and groundnut by removal of hemicelluloses, waxes, impurities and lignin and thus improved the mechanical properties of the fibres. The morphology of fractured surface observed by SEM suggests that the networking of structure restricts the pull out of fiber, which is responsible for higher mechanical properties for 40 % fiber content.

Mohanata and Acharya et al. [2] investigated the effect of stacking sequence of fibres in a hybrid composite containing luffa cylindrica-glass fibre. It was cited from observation that the tensile strength and flexural strength of hybrid composite with stacking sequence Glass fiber-Luffa-Luffa-Glass fibre was maximum among all possible combination of hybrid laminates. Scanning electron micrographs showed that failure of composite mainly due to pull out of the fibres for both luffa cylindrica and glass fibre.

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Dhanola and others et al. [3] fabricated polymer based composites with luffa fibers with and without natural fillers of ground nut shells, rice husk and wood powder. It has been studied that tensile strength of the composites decreases with the increase in filler loading except in case of ground nut shell filled composites. The composite with 30 % luffa fibre and 11% ground nut filler exhibited maximum ultimate tensile strength (31.5 MPa) compared to other filled and unfilled composites. The impact strength increased with the increase in the filler loading of the composites. Composite with 30% luffa fibre and 7% groundnut filler exhibited maximum impact strength (9 joules) when compared with other filled and unfilled composites. Hardness of the composites decreases with the increase in filler loading except in case of ground nut shell filled composites increases with the increase in filler loading. Composite 30 % luffa fibre and 11% ground nut filler has exhibited maximum hardness number (13.3 HVN). The rate of moisture absorption increases with increase in both fibers loading in both filled and unfilled composites. The minimum water absorption rate is observed for composite 30 % luffa fibre and 11% ground nut filler.

Anbukarasi and Kalaiselvam et al. [4] investigated the effect of fibre dimensions, fibre volume fraction (0.3–0.5V_f) and alkaline treatment of luffa fibres on various properties of composite. It was found that higher fibre volume fraction, poor wettability of fibre led to low mechanical strength in the composites. The composites containing 0.4V_f of treated mat fibre reinforced showed better mechanical properties compared with the other ones. Also non-homogeneous distribution of particles and single fibre in the matrix led to decrease in strength when compared with the mat fibre reinforced composite.

Parida, Das and Dash et al. [5] modified the luffa fibres by calcium phosphate and calcium carbonate separately. The XRD patterns indicated that the crystallinity and crystallite size of the composites decrease with increase in weight of fiber in the resin. Also mechanical properties were found to depend on adhesion between fibres and resin as well as fibre loading which requires more resin to wet the fibres in order to have effective mechanical properties.

Santos, Oliveria, Vieira and others et al.[6] evaluated surface treatment method for coir fibres based on 10 wt% sodium bicarbonate (NaHCO₃) solution for different periods of time (24, 96 and 168 h). It was concluded from the XRD analysis that the NaHCO₃ treatment was not as chemically aggressive as the traditional one with sodium hydroxide, proved itself efficient in increasing the stiffness of coir fibres and of their polyester and epoxy composites, being also less harmful to the environment after disposal. The NaHCO₃ treatment is not able to promote the structural change of cellulose-I to cellulose-II neither provided a significant increase in fibre roughness. However, there was degradation of hemicelluloses and pectin from the fibre surface. The alkaline treatment does not affect the mechanical strength of the composites since NaHCO₃ constitutes a mildly alkaline solution, which does not sensitively change the fibre surface and, thence, fibre-matrix adhesion. A higher impact resistance is observed for polyester composites in comparison to epoxy composites, owing to significant fibre pull-out, attributed to poorer fibre-matrix adhesion.

Santos, Siqueira, Vieira and others et al. [7] in another research also evaluated the effect of Sodium carbonate treatment on coir fibres. They found that the sodium carbonate treatment of coir fibres for 96 h provided significant enhancement in tensile and flexural strength of coir fibre reinforced epoxy and polyester composites. It was due to the removal of external amorphous compounds and increased exposure of crystalline cellulosic fibres. Moreover, the swelling of the internal structure led to a substantial densification of the fibres. These effects promoted a satisfactory increase of the tensile and flexural strength of the fibre reinforced composites for both polymeric matrices-epoxy and polyester studied. The alkali treatment also increased the superficial roughness of coir fibres, which increased interlocking of fibres. Thus there was increase in the tensile and flexural strength relative to untreated coir composites.

Shrivastava, Telang, Rana and Purohit et al [8] concluded from the synthesis and experimental analysis of mechanical properties and water absorption behaviour of the treated coir fiber and glass fiber reinforced epoxy polymer composite that Chemical treatment of coir fiber by NaOH leads to reduced moisture absorption behaviour of composite. Length of coir fiber and fiber loading, these two parameters also have measurable effect in mechanical properties. With increase in fiber content properties increases up to a certain limit after which it decrease. This can be explained as large fiber loading leads to improper bonding between fiber and matrix of composite. Fiber length also plays a major role. With

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use of 10 mm length of coir fiber mechanical properties are more than with 15 mm fiber. Curling of coir effect could be the reason of this reduction. So it is better to use short coir fiber than long fiber to avoid this curling effect of fibers.

Prajapati, Sharma and others et al. [9] prepared hybrid composite with treated coir and glass fiber reinforced epoxy polymer by hand layup method. It was seen that length of coir fiber and number of glass fiber layers affected the tensile and flexural strength of the developed composites. The small size coir fibers were found to be more effective as reinforcement and presented highest tensile strength owing to the absence of curling effect which facilitates better fiber matrix bonding. The tensile and flexural strength of composites increased with increase in numbers of glass fiber layers up to 3 layers beyond which it decreased, possibly because of improper fiber matrix bonding.

Potadar and kadam et al. [10] stated that the grain size as well as the type of fibre significantly influences the mechanical properties as well as moisture absorption capabilities of concerned composites. The highest tensile strength was found for a particulate grain size of 1 mm for both, groundnut fibre composites as well as coir fibre composites; however coir fibre composites had comparatively higher tensile strength than groundnut fibre composites. When it comes to higher flexural strength, again the particulate grain size of 1 mm provided the same for both, groundnut fibre composites as well as coir fibre composites; also coir fibre composites had comparatively flexural tensile strength than groundnut fibre composites. Considering the moisture absorption capability, the particulate grain size of again 1 mm provided the same at lowest rate for both, groundnut fibre composites as well as coir fibre composites; but groundnut fibre composites revealed lower moisture absorption capability than coir fibre composites thus making it more suitable. Overall, coir fibre composites are comparatively better than groundnut fibre composites as far as mechanical properties are concerned.

Valasek, Amato and others et al. [11] examined the properties of brown and the white coconut coir. The suitable alkali treatment with 6% water solution of NaOH for 12 h increased their tensile strength and the elastic modulus. It was certified by SEM analysis. The alkali treatment would lead to the improvement of the observed characteristics. It found that the brown fibres reach higher tensile strength than the white fibres. The composite systems created with brown fibres reaches to better mechanical characteristics overall.

IV. CONCLUSION

The review endeavour aimed at exploring the scope of using Luffa fibre and Coconut coir as reinforcement in epoxy composites. This review suggested that hybrid composite or composite with fillers can also be fabricated with Hand layup technique successfully. The strengths of the fibre can be improved by chemical treatment. The Alkali treatment with NaOH is found to be the most common and effective alkali treatment method compared to ones with NaHCO_3 and Na_2CO_3 . The effect of alkali treatment was found to be enhancing the properties of fibre up to certain limit with passage of time. The further increase in exposure time led to the decrease in the mechanical strength of the fibre. It could be concluded that the results were found to be better when NaOH solution was used in the range of 2-10% for specified time period to achieve successful treatment of fibres. Increasing fibre content beyond a point showed lack of proper bonding of fibres with matrix and thus, low strength. Increase of filler material up to a certain limit has proven to increase the mechanical strength of composites. It is suggested to have shorter lengths of coir to avoid curling which could lead to improper load transfer in composite.

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