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Coir Fibre Reinforcement and Application in Polymer Composites: A Review

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Abstract

Increasing concern about global warming and depleting petroleum reserves have made scientists to focus more on the use of natural fibres such as bagasse, coir, sisal, jute etc. This has resulted in creation of more awareness about the use of natural fibres based materials mainly composites. In past decade there has been many efforts to develop composites to replace the petroleum and other non decaying materials based products.The abundant availability of natural fibre in Indiagives attention on the development of natural fibre composites primarily to explore value-added application avenues.Reinforcement with natural fibre in composites has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of separation, enhanced energy recovery, $C0_2$ neutrality, biodegradability and recyclable in nature. Agricultural wastes can be used to prepare fibre reinforced polymer composites for commercial use. Although glass and other synthetic fibre-reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of production. In this connection, an investigation has been carried out to make use of coir; a natural fibre abundantly available in India.This review discusses the use of coir fibre and its current status of research. Many references to the latest work on properties, processing and application have been cited in this review.

Keywords: Natural Fibre, Coir, Epoxy resin, Polymer Composites.

1. Introduction

1.1 Requirement of Composites:

Over a past few decades composites, plastics, ceramics have been the dominant engineering materials. The areas of applications of composite materials have grown rapidly and have even found new markets. Modern day composite materials consist of many materials in day to day use and also being used in sophisticated applications while composites have already proven their worth as weight saving materials the current challenge is to make them durable in tough conditions to replace other materials and also to make them cost effective.This has resulted in development of many new techniques currently being used in the industry. The composite industry has begun to recognise the various applications in industry mainly in the transportation sector.

New polymer resin matrix materials and high performance fibres of glass, carbon and aramid which have been introduced recently have resulted in steady expansion in uses and volume of composites. This increase has resulted in obvious reduction of cost. High performance FRP are also found in many diverse applications such as composite armouring design to resist the impact of explosions, wind mill blades, industrial shafts, and fuel cylinders for natural gas vehicles paper making rollers and even support beams of bridges. Existing structures that have to be retrofitted to make them seismic resistant or to repair damage caused by seismic activity are also done with help of composite materials.

While the use of composites is a clear choice in many applications but the selection of materials will depend on the factors such as working life, lifetime requirements complexity of product shape, no of items to be produced , savings in terms of cost and the experience and skill of designer to trap the optimum skill of the composites.

1.2 Composites: A definition

A composite material is made by combining two or more materials to give a unique combination of properties, one of which is made up of stiff, long fibres and the other, a binder or 'matrix' which holds the fibres in place.

Kelly [1] very clearly stated that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Beghezan [2] defined as "The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings", in order to obtain improved materials.

Van Suchetclan [3] explained composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property**.**

1.3. Composites Properties:

Composites consist of one or more discrete phases embedded in a continuous phase to produce a multiphase material which possesses superior properties that are not obtainable with any of the constituent materials acting alone. These constituents remain bonded together but retain their identity and properties. The continuous phase which is present in greater amount in composites is termed as 'matrix'. The discrete phase is generally harder and stronger than the continuous phase and is called the 'reinforcement' or 'reinforcing material'. The geometry of the reinforced phase is one of the major parameter in determining the effectiveness of the reinforcement.

Properties of composites are strongly depend on the characteristics of their constituent materials, their distribution and the interaction among them Further, the need of composite for high strength to weight ratio, corrosion resistance, lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases weight but also absorbs the shock & vibrations through tailored microstructures. Modern and ancient applications all make use of the fact that composites can possess enhanced strength, stiffness and fracture, toughness whilst not exhibiting an increase in weight. Composites are being used for prefabricated, portable and modular buildings as well as for exterior cladding panels.

Table 1 shows the cellulose and lignin contents and some other properties of a few fibres available in India. So far, the utilisation of sisal, jute, coir and bagasse fibres has found many successful applications.

1.4. *Composites constituents:*

Most composites consist of a bulk material ('matrix') and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix.

Matrices [5] materials in composites are required to fulfill the following functions:

a) To bind together the fires by virtue of its cohesive and adhesive characteristics
b) To protect them from environments and handling.
c) To disperse the fibers and maintain the desired fiber orientation and spacing.
d) To transfer stresses to the fibers by adhesion and/or friction across the fiber-matrix interface when the composite is under load, and thus to avoid any catastrophic propagation of cracks and subsequent failure of composites.
e) To be chemically and thermally compatible with the reinforcing fibers.
f) To be compatible with the manufacturing methods which are available to fabricate the desired composite components.

1.4.1Thermoset polymer matrices

Thermosetting polymers are resins which change irreversibly under the influence of heat into an infusible and insoluble material by the formation of covalently cross-linked stable networks.Important thermosetting

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resins are unsaturated polyesters, epoxy resins, alkyds, vinyl esters and alkyl resins, amino plastics, urethanes, silicones etc.

Table1: Properties of some vegetable fibres used in India for composites [4]

Fibre	Cellulose content (%)	Lignin content (%)	Dia (µm)	UTS (MN/m^2)	Elongation Max. (%)	Elastic Modulus
Banana	64	5	50-250	700-780	3.7	27-32
Sisal	70	12	50-200	530-630	5.1	17-22
Pineapple	85	12	20-80	360-749	2.8	24-35
Coir	37	42	100-450	106-175	47	3-6
Talipot	68	28	80-800	143-263	5.1	10-13
Polymer	40-50	42	70-1300	180-250	2.8	4-6

1.4.2 Epoxy resins

Epoxy resins are characterized by the presence of more than one1, 2- epoxide groups per molecule. Cross-linking is achieved by introducing curatives that react with epoxy and hydroxyl groups situated on adjacent chains.

Advantages and Limitations of resin matrix

Advantages	Limitations
1. Low Densities	1. Low Transverse Strength.
2. Good Corrosion Resistance	2. Low Operational Temperature Limits
3. Low Thermal Conductivities	
4. Low Electrical Conductivities	
5.Translucence	
6.Aesthetic Color Effects	

1.4.3 Reinforcement

The objective of the reinforcement in a composite material is to enhance the mechanical properties of the resin system. All of the distinct fibres that are used in composites have distinct properties and so affect the properties of the composite in different ways. For most of the applications, the fibres need to be arranged into some form of sheet, known as a fabric, to make handling possible.

1.4.4 Ceramic Matrix

Ceramic materials are inorganic, non-metallic materials made from compounds of a metal and a non-metal. They are formed by the action of heat and subsequent cooling. Clay was one of the earliest materials used to produce ceramics. Ceramic materials tend to be strong, stiff, brittle, and chemically inert and non-conductors of heat and electricity, but their properties vary widely. For example, porcelain is widely used to make electrical insulators. Ceramics have poor properties in tension and shear. Ceramic Matrix Composites (CMCs) used in very high temperature environments, these materials use a ceramic as the matrix and reinforce it with short fibres, or whiskers such as those made from silicon carbide and boron nitride.

***1.5** Composites: A Classification*

Composite materials can be classified in different ways [4], a typical classification is presented in Fig1.1 [47]. The two broad classes of composites are (1) Particulate composites and (2) Fibrous composites.

1.5.1Particulate composites

A particulate composite is composed of particles suspended in a mixture.As the name signifies itself that reinforcement is of particle nature. It may be spherical, cubic, tetragonal, a platelet, or other shape, but it is approximately equal. Normally, particles that are not very effective in improving fracture resistance, they increase the stiffness of the composite to a limited extent.There are two subclasses of particulates, flake and filled/skeletal. A flake composite is generally composed of flakes with large ratios of platform area to thickness, suspended in a matrix material. A filled/skeletal composite is composed of a continuous matrix filled. Particle fillers are widely used to improve the properties of matrix materials to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage.

1.5.2 Fibrous composites

A fiber is defined by its length which is much greater than its cross-sectional dimensions. Fibers are very effective in improving the fracture resistance of the matrix because reinforcement having a long dimension opposes the growth of cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices.

Fibers, because of their small cross- sectional dimensions, are not directly usable in engineering applications. They are, therefore, embedded in matrix materials to form fibrous composites. The matrix serves to bind the fibers together, transfer loads to the fibers and protect them against environmental attack and damage due to handling.

Fibrous composite can be subdivided into - continuous fiber (large aspect ratio), discontinuous (short) fiber (low aspect ratio) and hybrid.

1.5.2.1 Continuous fibers

Continuous fiber composites can be either single layer or multilayered. The single layer continuous fiber composites can be either unidirectional or woven, and multilayered composites are generally referred to as laminates. The material response of a continuous fiber composite is generally orthotropic.

1.5.2.2 Discontinuous fibers

Material systems composed of discontinuous reinforcements are considered single layer composites. The discontinuities can produce a material response that is anisotropic, but in many instances the random reinforcements produce nearly isotropic composites.

1.5.2.3 Hybrid fibers

These are the combination of more than one fiber.

1.6. Natural fibre composites

Natural fibre composites mostly consists fibres of jute, cotton, hemp and non conventional fibres such as coir and many empty fruit bunches. Natural fibre thermoplastic composites are attractive as they are cheaper, stiffer, paintable, rot-resistant and also can be given the look of wood in addition to all this they have more life- cycle. Natural fibre composites are attractive to industry because of their low density and ecological advantages over conventional composites Natural fibres are lingo cellulosic in nature. These composites are gaining importance due to their non-carcinogenic and bio-degradable nature. Natural fibre composites are very cost effective material especially in building and construction purpose packaging, automobile and railway coach interiors and storage devices. These can be potential candidates for replacement of high cost glass fibre for low load bearing applications. Table 2 shows the availability of natural fibers in India.

Coir is a natural fibre extracted from the husk of Coconut fruit (Fig. 1.2). The husk consists of Coir fibre and a corky tissue called pith. It is a fibre abundantly available in India the second highest in the world after Philippines. It consists of water, fibres and small amounts of soluble solids. The Table [3] shows the percentage contribution of each of these fibres.

Because of the high lignin content coir is more durable when compared to other natural fibres. With increasing emphasis on fuel efficiency, natural fibres such as coir based composites enjoying wider applications in automobiles and railway coaches & buses for public transport system. There exist an excellent opportunity in fabricating coir based composites towards a wide array of applications in building and construction such boards and blocks as reconstituted wood, flooring tiles etc. Value added novel applications of natural fibres and coir based composites would not go in a long way in improving the quality of life of people engaged in coir cultivation, but would also ensure international market for cheaper substitution.Natural fibres have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fibres and matrix and the relative high moisture sorption. Therefore, chemical treatments are considered in modifying the fibre surface properties.

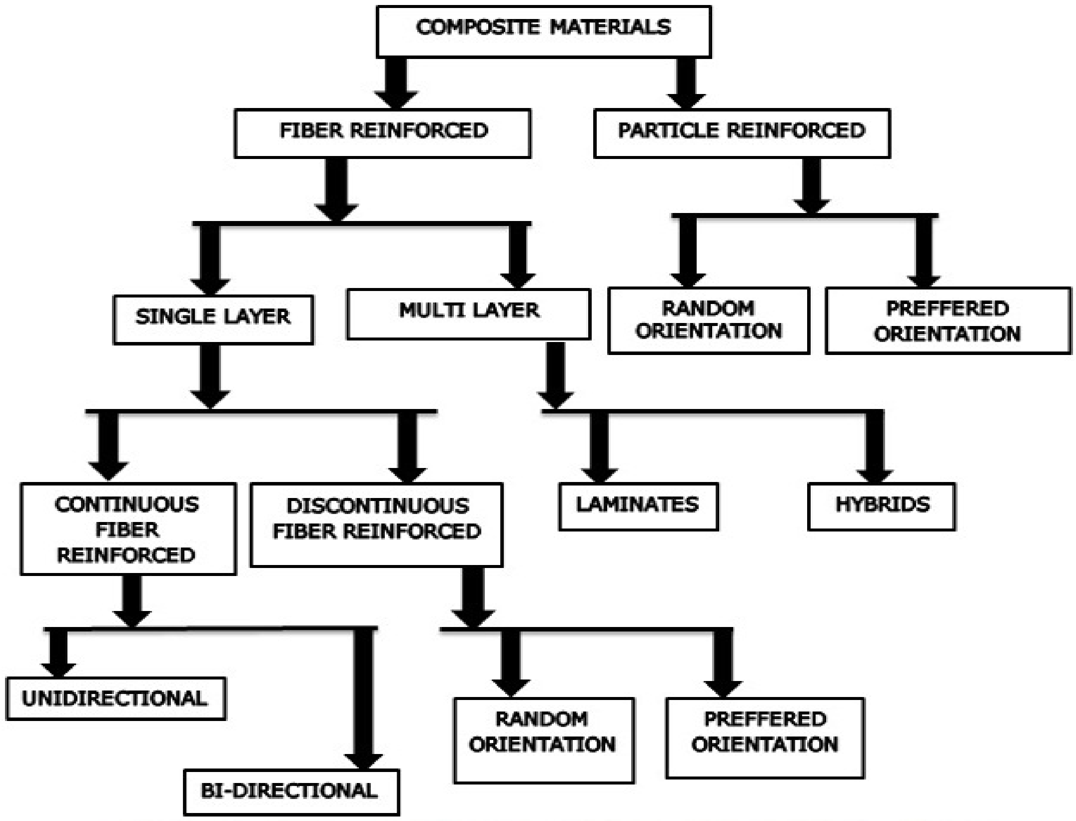

Fig.1.1: Classification of Composites [47]

Table 2 Availability of natural fibre in India and its applications [5]

Item	Source	Qty. in Mt/Yr.	Application
Rice Husk	Rice mills	20	As fuel, for manufacturing building materials and products for production of rice husk binder, fibrous building panels, bricks, acid proof cement
Banana leaves/stalk	Banana plants	0.20	In the manufacture of building boards, fire resistance fibre board
Coconut husk	Coir fibre industry	1.60	In the manufacture of building boards, roofing sheets, insulation boards, building panels, as a lightweight aggregate, coir fibre reinforced composite, cement board, geo-textile, rubberized coir
Jute fibre	Jute Industry	1.44	For making chip boards, roofing sheets, door shutters
Rice/wheat straw	Agricultural farm	12.00	Manufacture of roofing units and walls panels/boards

Table3 [10] Chemical composition of Coir:

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%

A better understanding of the chemical composition and surface adhesive bonding of natural fibre is necessary for developing natural fibre-reinforced composites. The components of natural fibres include cellulose, hemicelluloses, lignin, pectin, waxes and water soluble substances. The composition of selected natural fibres is shown in Table2. The composition may differ with the growing condition and test methods even for the same kind of fibre.Cellulose is a semi crystalline polysaccharide made up of D-glucopyranose units linked together by β-(1-4)-glucosidic bonds [11] and the large amount of hydroxyl group in cellulose gives natural fibre hydrophilic properties when used to reinforce hydrophobic matrix; the result is a very poor interface and poor resistance to moisture absorption [12]. Hemicellulose is strongly bound to cellulose fibrils presumably by hydrogen bonds. Hemicellulosic polymers are branched, fully amorphous and have a significantly lower molecular weight than cellulose. Because of its open structure containing many hydroxyl and acetyl groups, hemicellulose is partly soluble in water and hygroscopic [13]. Lignins are amorphous, highly complex, mainly aromatic, polymers of phenyl propane units [11] but have the least water sorption of the natural fibre components [12]. Because of the low interfacial properties between fibre and polymer matrix often reduce their potential as reinforcing agents due to the hydrophilic nature of natural fibres, chemical modifications are considered to optimize the interface of fibres. Chemicals may activate hydroxyl groups or introduce new moieties that can effectively interlock with the matrix. The development of a definitive theory for the mechanism of bonding by chemicals in composites is a complex problem. Generally, chemical coupling agents are molecules possessing two functions. The first function is to react with hydroxyl group of cellulose and the second is to react with functional groups of the matrix.
Visualizing the increased rate of utilization of natural fibres the present work has been undertaken to reviewdevelopment of a polymer matrix composite (epoxy resin) using coir fibre as reinforcement and to studyof its mechanical properties and environmental performance. The composites were prepared with different fraction of coir fibres.

Fig.1.2 Coconut Husk

2. Literature Survey:

Researchers have begun to focus attention on natural fibre composites (i.e., coir fibre), which are composed of natural or synthetic resins, reinforced with natural fibres. Natural fibres exhibit many advantageous properties, they are a low-density material yielding relatively lightweight composites with high specific properties. These fibres also have significant cost advantages and ease of processing along with being a highly renewable resource, in turn reducing the dependency on foreign and domestic petroleum oil.Harinth Aireddy et al [14] Investigatedcoir dust reinforced epoxy matrix composites of different compositions. The abrasive wear property of the composites were examined in dry conditions on a pin-on-disc machine against 400μm grit size abrasive paper, with test speed of 0.540 m/sec and normal loads of 5,10,15,20, and 25N.The experimental results shown that, the abrasive wear resistance of the composite depends on the coir dust concentration, sliding distance and applied normal load. wear mechanism was dominated by reinforcement because of higher coir dust loading.The abrasive wear resistance decreased with increase in normal load and increased with increasing coir dust concentration. S.mazan et al. [15] studied the viability of coir fibre reinforced composites in sound absorption panel. The composites are constructed as prescribed percentage of fillers and polyurethane as resin. Two microphone methods were used to investigate the acoustic the properties of the material. The result demonstrates good acoustic properties of the composites and highlight the potential of the coir fiber reinforced composites in sound absorption panel.

Slate [16] investigated mechanical properties of coir fibre reinforced cement sand mortar. The researcher tested two different design mixes (cement sand ratio by weight), first was 1:2.75 with water cement ratio of 0.54 and second was 1:4 with water cement ratio of 0.82. Fibres content was 0.08, 0.16 and 0.32 % by total weight of cement, sand and water. The mortars for both design mixes without any fibres were also tested as reference. Cylinders having size of 50 mm diameter and 100 mm height and beams having size of 50 mm width, 50 mm depth and 200 mm length were tested for compressive and flexural strength. The curing was done for 8 days only. ASTM standards were used (C196-72, C78-64, C39-71 and C109-73). It was found that all strengths were increased in case of fibre reinforced mortar as compared to that of plain mortar for both mix design with all fibre contents. However, a decrease in strength of mortar was also observed with an increase in fibre content. Sabu Thomas et al (1998) [polymer3] investigated the effect of chemical modification, loading and orientation of fibre. In this study Interfacial adhesion between coir and natural rubber (NR) was improved by treatment of the coir fibres with alkali (sodium hydroxide and sodium carbonate) and NR solution, and by the incorporation of HRH/RH bonding systems. Composites containing 10 mm long coir fibres were vulcanized at 150°C according to their respective cure times. Green strength measurements were carried out to measure the extent of fibre orientation. Sabu Thoms et al [17] studied the dynamic and mechanical properties of short coir reinforced natural rubber composites. Maxima in tan δ, E″ and the middle point of E′ vs. temperature curves of the gum natural rubber compound at different frequencies almost coincide with one another. But the maxima in tan δ and E″ do not coincide in the case of composites. It is observed that as frequency increases the values of tan δ and E″ decrease whereas the values of E′ increase in the case of both gum and the composites. The values of E″ and tan δ increase with fiber incorporation, which indicates lower heat dissipation in the gum. Two prominent peaks are observed in the tan δ vs. temperature curve of these composites due to the dynamic mechanical behaviour of matrix and fiber. The additional small peak represents the dynamic mechanical behaviour at the interface. The effect of chemical treatment of coir fiber on damping of composites was studied and it was found that composite with poor interfacial bonding tend to dissipate more energy than that with good interfacial bonding. Li et al. [18] studied untreated and alkalized coconut fibres with two lengths of 20 and 40 mm in cementitious composites as reinforcement materials. Mortar was mixed in a laboratory mixer at a constant speed of 30 rpm, with cement: sand: water: super plasticizer ratio of 1: 3: 0.43: 0.01 by weight and fibres were slowly put into the running mixer. Australian standards AS 1012.8.1- 2000 and 1012.8.2-2000 were used. The resulting mortar had better flexural strength, higher energy absorbing ability and ductility, and lighter than the conventional mortar. Good results were achieved with the addition of a low percentage of coconut fibres and chemical agents in cementitious matrix. Reis [19] investigated the mechanical characterization (flexural strength, fracture toughness and fracture energy) of epoxy polymer concrete reinforced with natural fibres (coconut, sugarcane bagasse and banana fibres).RILEM standards TC-113/PC2, TC 89-FMT, TC50-FMC and TC-113/PCM-8 were followed. Fracture toughness and fracture energy of coconut fibre reinforced polymer concrete were higher than that of other fibres reinforced polymer concrete. And flexural strength was increased up to 25 % with coconut fibre only. Misra et al [20] investigated fire retardant coir epoxy micro-composites. The coir fibre is treated with saturated bromine water for increasing the electrical properties and then mixed with stannous chloride solution for improving the fire retardant properties only 5% of fire retardant filler reduces the smoke density by 25% and the LOI value increases to 24%. The mechanical properties of the composites were not affected much after the incorporation of fillers. Flexural strength and flexural modulus of the composite increased tremendously. Multiquadric radial basis function (MQRBF) method is applied for static and dynamic analysis of coir epoxy micro-composite plate under uniformly distributed load. Bujang et al [21] studied the dynamic characteristics of coir fibre reinforced composites.Composites with volumetric amounts of coconut fibre up to 15% were fabricated and they were arranged in randomly oriented discontinues form. Tensile test was carried out to determine the strength of material, while experimental modal analysis was executed to obtain the dynamic characteristics of the composite material. The acquired results show that the tensile modulus changes with the fibre content. The strength of coconut fibre reinforced composites tends to decrease with the amount of fibre which indicates ineffective stress transfer between the fibre and matrix. The stiffness factor also gives the same effect to the dynamic characteristic of composite where the natural frequency decreased with the increase of coconut fibre volume. However the damping peak was found to be increased by the incorporation of the fibre. When higher fibre content of 10% was used, the damping peak shows the maximum value for almost all the frequency mode. It was observed that theeffects of reinforcing polyester matrix with the coconut fibres caused the composites to be more flexible and easily deform due to high strain values and reduction of high resonant amplitudeindicated that hybrid composites offer better resistance to water absorption. This work demonstrates the potential of the hybrid natural fibre composite materials for use in a number of consumable goods. J.R.M. D. Almeida et al [22] investigated the structural characteristics and mechanical properties of coir fibre/polyester composites. The coir fibres were obtained from disregarded coconut shells that if not properly processed constitute an environmental hazard. The as-received coir fibre was characterized by scanning electron microscopy coupled with X-ray dispersion analysis. Composites prepared with two moulding pressures and with amounts of coir fibre up to 80 wt. % were fabricated. Up to 50 wt. % of fibre, rigid composites were obtained. For amounts of fibre higher than this figure, the composites performed like more flexible agglomerates. Chanakan Asasutjarit et al. [23] studied the effects of pre-treatment of coir fiber for manufacturing coir-based green composites. Composites were prepared using coir fiber treated with varying pre-treatment condition. The process ability conditions and physical, mechanical and thermal characteristics of these composites were analysed. Surface characterizations of the un pre-treated and pre-treated coir fiber were investigated from scanning electron microscopy (SEM) studies. It revealed that there is an improved adhesion between fiber and matrix in the case of pre-treated coir. SEM investigations confirm that the increase in properties is caused by improved fiber-matrix adhesion. Syed H. Imam et al [24] studied the Effect of fiber treatments on tensile and thermal properties of coir bio composites Coir fibres received three treatments, namely washing with water, alkali treatment (mercerization) and bleaching. Treated fibres were incorporated in starch/ethylene vinyl alcohol copolymers (EVOH) blends. Mechanical and thermal properties of starch/EVOH/coir bio composites were evaluated. Fiber morphology and the fiber/matrix interface were further characterized by scanning electron microscopy (SEM). All treatments produced surface modifications and improved the thermal stability of the fibres and consequently of the composites. The best results were obtained for mercerized fibres where the tensile strength was increased by about 53% as compared to the composites with untreated fibres, and about 33.3% as compared to the composites without fibres. The mercerization improved fiber–matrix adhesion, allowing an efficient stress transfer from the matrix to the fibres. The increased adhesion between fiber and matrix was also observed by SEM. Treatment with water also improved values of Young's modulus which were increased by about 75% as compared to the blends without the fibres. Thus, starch/EVOH blends reinforced with the treated fibres exhibited superior properties than neat starch/EVOH. Hairul Abral, et al [25]analysed the Fracture surface of coir fibres reinforced composite processed under vacuum variations Volume fraction of fiber content in the composite was determined as much as 6%. Resin and fibres were manually mixed at room temperature and the mixing was vacuumed in a vacuum chamber by vacuum variations of -300 mmHg, -400 mmHg and -500 mmHg. As control, the composite was also made under condition of 760 mmHg (1 atm) pressure. The investigation shows the result that many fibres of composite processed by 1 atmosphere were pull out from matrix without availability of residual resin sticky on fiber surface. On the contrary, many resins stuck strongly on fiber surface of the composite made under vacuum were found. A. Bensely et al [26] investigated the mechanical properties of coir fibre composites. In the present work, coir composites are developed and their mechanical properties are evaluated. Scanning electron micrographs obtained from fractured surfaces were used for a qualitative evaluation of the interfacial properties of coir/epoxy and compared with glass fiber epoxy. These results indicate that coir can be used as a potential reinforcing material for making low load bearing thermoplastic composites. Sarocha Charoenvai et al [27] investigated the mechanical properties of coir based green composites were prepared using coir fiber treated with varying pre-treatment condition. The changes in the proportion of chemical composition and morphological properties of coir fibres with different coir pre-treatment condition were discussed. It is observed that the mechanical properties of coir-based green composites; modulus of rupture and internal bond, increase as a result of chemical composition modification and surface modification. Scanning electron microscopy (SEM) investigations show that surface modifications improve the fiber/matrix adhesion. Abrahams P. Mwasha1 et al [28] investigated the time dependent behaviour of basal-reinforced embankments erected on soft ground using biodegradable geotextiles, coir fibre, derived from coconuts, as reinforcing materials. An analytical model for soil reinforcement, which incorporates changes of foundation soil strength over time due to consolidation, is analyzed using the GEO5 slope stability computer software. and calculated the initial strength required to achieve a specified factor of safety. Cervalho et al [29] studied the effect of chemical modification in on the effect of coconut fibre composites lignocellulose fibres from green coconut fruit were treated with alkaline solution (NAOH 10%m/v) and then bleached with sodium chlorite and acetic acid. Alkali treated bleached fibres were mixes with high impact strength polystyrene (HPIS) and placed in injector chamber to obtain the specimen for tensile test. Specimens were tested in tensile mode and fracture surfaces of composites were analysed by scanning electron microscope and x-ray diffraction. The results showed that the addition of 30% alkali-treated and bleached fibres reinforced in HPIS matrix provide considerable change in mechanical properties in comparison of pure HPIS.H.P.G. Santafé Júnior et al [30] investigated the tensile properties of post-curedpolyester matrix composites incorporated with the thinnest coir fibres. Tensile specimens with up to 40% in volume of long andaligned coir fibres were tested and their fracture analyzed by scanning electron microscopy. A relatively improvement was found in the tensile properties for the amount of 40% of coir fibre. S Jayabal et al[31] investigated mechanical and machinability characteristics of coir fibreusing Taguchi method. The regression equations were developed and optimized for studying drilling characteristics of coir–polyester composites using the Taguchi approach. A drill bit diameter of 6 mm, spindle speed of 600 rpm and feed rate of 0·3 mm/rev gave the minimum value of thrust force; torque and tool wear in drilling analysis. The short coir–fibre-reinforced composites exhibited the tensile, flexural and impact strength of 16.1709 MPa, 29.2611 MPa and 46.1740 J/m, respectively The regression equations were developed and optimized for studying drilling characteristics of coir–polyester composites using the Taguchi approach. A drill bit diameter of 6 mm, spindle speed of 600 rpm and feed rate of 0·3 mm/rev gave the minimum value of thrust force, torque and tool wear in drilling analysis . Sanjay Kindoet al [32] investigated development and characterization of a new set of natural fibre based polymer composites consisting of coconut coir as reinforcement andepoxy resin. The newly developed composites are characterized with respect to their mechanical characteristics. Experiments are carried out to study the effect of fibre length on mechanical behaviour of these epoxy based polymer composites. In the present work, coir composites are developed and their mechanical properties are evaluated. Scanning electron micrographs obtained from fractured surfaces were used for a qualitative evaluation of the interfacial properties of coir-epoxy. These results indicate that coir can be used as a potential reinforcing material for many structural and non-structural applications. A.Z., Ahmad mujahid et al [33] performed the experimental modal analysis on coir fiber reinforced composites. There are 4 percentages of the coir fibre that will be used to fabricate the composites which 40% wet, 50% wet, 60% wet and 70% wet of coir fibre. Dynamic characteristic of the composite are evaluated . For all the cases, the plate only experiences the global vibration where the whole structure is vibrating. The first five mode shapes of each percentage of coir fibre were observed which can be identified from 39.8 Hz until 985 Hz. From the result, the natural frequencies of 40% wet fibre are observed where can be identified from frequency 315 Hz until 985 Hz. The natural latex with the 40% volume of coir fibres shows a slightly higher frequency compared to 70% volume of coir fibres only for the second until five mode frequency. Somehow for the higher mode, it founds that the natural latex with 70% fibres volume prove to have a higher value. The results were found that the dynamic characteristics are greatly dependent on the volume percentage of fibres. From the result, it can be concludes that the sample with 40% coir fibre gives the highest value of natural frequency which is 315 Hz to 985 Hz compared the others composition. The increase of coir fibres will make the composite tend to have low stiffness and ductility. A.zuradia et al [34] investigated the effect of fibre length on mechanical properties of coir fibber reinforced cement-album composites. The experiment presented that the increasing the length of fibre increases the flexural strength. But incorporation of long fibre into the cement past reduced the workability thus introduced voids result in low density in fact water absorption and water content also increased. Syed Altaf Hussain et al [35] studied the mechanical properties of green coconut fibre reinforced HDPE polymer composite material green coconut fibre reinforced HDPE polymer composite material. the test specimen were produced according Taguchi's L9 orthogonal arrayconcept. The control parameters considered were fibre volume fraction and fibre length. Mechanical properties were attempted to be modelled through response surface methodology. Validity of the model was checked through analysis of variance. The results indicated that the developed modelsare suitable for prediction of mechanical properties of green coconut fibre reinforced HDPE composite. Alida Abdullah et al [36] studied the effect of natural fibre content on the physical andmechanical properties as well as fracture behaviour of cement reinforced with coir fibre composite. The mix design was based on 1:1 for cement: sand ratio and 0.55 was fixed for amount of water percement ratio. coir fibre was added as reinforcement to replace the composition of sand. Composites were developed based on 3 wt. %, 6 wt. %, 9 wt. %, 12 wt. % and 15 wt. % of coir fibre by mixing and curing process. Composites were cured in water for 7, 14, and 28 days. It was reported that the composite reinforced with 9 wt. % of coconut fibre demonstrated the highest strength of modulus of rupture and compressive strength. S Jayabalet al [37] studied the properties of woven coir–glass hybrid polyester composites. The composites were prepared and their mechanical properties were evaluated for different staking sequence. Scanning electron micrographs of fractured surfaces were used for a qualitative evaluation of interfacial properties of woven coir–glass hybrid polyester composites. These results indicated that coir–glass hybrid composites offered the merits of both natural and synthetic fibres. R. Saravanan [38] investigated the effect of acidic and alkaline environment curing of concrete on coir reinforced bio-composite concrete panels. The experimental programmeme consists of slabs of length 750mm, 500mm width and 40 mm thick. Two different grades of concrete M20 and M30 are cast. The Percentage of reinforcement used in the slabs is 0.95%, 1.43% and 1.91% which are arrived from the three percentage of coir fibre volume fraction (0.5%, 0.75% and 1.0%). This experimental program consists of determination of mass loss and strength deterioration against HCL and Na_2SO_4 attacks of slab specimens. From the studies, 5% reduction due to HCl acid attack and 2% reduction due to Na_2SO_4 for coir rope and 1% reduction due to HCl acid attack and 2% reduction due to H_2SO_4 for coir rope coated with epoxy resin were observed. The micro-structural properties of fresh natural fibres in as received condition and natural fibres reacted with concrete under accelerated curing conditions for two years were also ascertained. SEM and EDAC tests were conducted on reacted as well as received natural fibres and results concluded that the development of bio-composite sandwich concrete panels is possible. They moderate performance under flexure was obtained in all the bio-composite specimens. Flexural performance of epoxy coated Coir reinforced bio-composite panels is higher than plain coir rope panels. This also is proved in microstructural studies. Effect of acid environment affect the flexural performance of coir as well as epoxy coated coir ropes around 2%. While taking the sulphate environment, the reduction in flexural performance is 3 to 4% in average. Hence not much deviation was occurred in the flexural performances. Also from microstructural studies, it is observed that, the walls were not affected by the acid or sulphate environment. So, durability of proposed coir rope reinforced bio-composite concrete panels is good.

C.H.Chandra Rao et al [39] investigated the wear behavior of treated and untreated coir dust filled epoxy resin matrix composites. The effect of treated and un treated coir dust concentration (10%, 20% and 30%), varying loads (10, 20 and 30N) and varying velocities (300, 400 and 500) on the abrasive wear rate of composite has been analysed. The abrasive wear property of the composite is examined on a pin-on-disc machine against 400μm grit size abrasive paper with test. To minimize the experimental time and cost of investment taguchi method model L9 is selected. However, it is found that the treated fiber composite shows better wear resistance than the untreated fiber composites. Abrasive wear rate is decreased with increasing the coir dust amount. As the load increase the wear rate increases also observed similar. Yingcheng Hu et al (2012) [40] studied the different weight proportions of coir fibres added to wood particle debris to produce hybrid boards the two forms of coir fibres used were random distribution and random matt. The mechanical and sound absorption performances were evaluated. Experimental results provide the evidence that the addition of coir fibres enhance the mechanical and sound absorption of the mechanical boards. The non-woven needle mat form was in particularly effective in evenly distributing the fibre. The sufficient strength and sound absorbing material made them suitable to be used in inner walls of automotive applications. Sangita mullick et al. [41] studied the effect of alkali treatment on coir fiber composites. Coir fibre is treated with alkali for the improvement of the fibre properties. In order to measure all the effects on the coir fibre composite due to the alkali treatment various characterising tools such as XRD, SEM, FTIR and flexural tests are carried out. As a result of the treatment the improvement on the surface of the fibre is observed due to the reduction of the impurities, lignin content etc. which is confirmed by SEM analysis an increase in fibre strength is also obtained which may be due to better fibre-matrix adhesion. A decrease in degree of crystallinity is observed during XRD analysis. However increased physical and mechanical properties are observed due to the alkali treatment on the coir fibre. R. Zulkifli et al [42] studied the acoustic properties of natural organic fibres; kenaf and coir fibres using impedance tube method. Kenaf fibre was used as noise absorber filler in an insulation panel while the coir fibre as reinforcement in the perforated composite panel. The perforated panel was made from coir fibre/polyester composites with coir fibre volume fraction of 10%, 20% and 30%. The perforation area of the perforated panel was also varied at 10%, 20% and 30%. During the processing stage, the kenaf fibre sheet has been treated with PVA and cut into 100 mm and 30 mm diameter sample for low and high frequency test. The density of the coir fibre is determined to be 32.2 g/cm3 while the density of the kenaf fibre is 42.6 g/cm3. The results obtained show that the optimum noise absorption coefficient index for kenaf fibre is 0.8 with 10% fibre volume fraction of coir fibre/polyester perforated composites panel at 10% perforation areas. Rahul A.khan et al [43]studied the mechanical properties of coir fiber ethylene glycol dimethacrylate base composites Tensile strength (TS), Young's modulus (YM) and elongation at break (Eb%) of virgin coir fibres were found to be 152 MPa, 5.3 GPa and 36%, respectively. Coir fibres were treated with ultraviolet (UV) radiation and were found to improve the mechanical properties significantly. Coir fiber-reinforced ethylene glycol dimethacrylate (EGDMA)-based composite was prepared and characterized. The surface of the coir fibres was modified with monomer EGDMA under UV radiation. Soaking time, monomer (EGDMA) concentration and radiation intensities were optimized over mechanical properties. The highest values of TS, YM, Eb and polymer loading (PL) were found for 50% EGDMA at 125th pass of UV radiation for 7 min soaking time. Pre-treatment with UV radiation on the coir fiber was found to be more effective for the increment of its mechanical properties. The surface of the fiber was also mercerized (alkali treatment) using aqueous NaOH solutions (5–50%) at varied time and temperature. It was found that TS of the mercerized composites increased with the increase in NaOH solutions (up to 10%) and then decreased. The composites made using mercerized fibres treated with EGDMA showed further increase in TS. Pre-treatment with mercerization + UV treatment of coir fiber showed significant improvement in the mechanical properties of the coir fiber-based composites. Dixit S. et al [44] studied the effect of hybridization on mechanical properties of coir. Composites fabrication was done using compression moulding technique. The results demonstrated that hybridization plays an important role for improving the mechanical properties of composites. The tensile and flexural properties of hybrid composites are improved markedly as compare to unhybrid composites. Shehamayee das et al [45] bleach treated coir fibre and then cast them with epoxy resin using handmade mould. XRD patterns confirmed that degree of crystallinity decreases by the treatment of coir fibre with H_2O_2. SEM image shows roughness of surface structure of composites which confirms that the adhesion is increased after treatment. FTIR spectra confirm that water content of composites decreases due to intermolecular hydrogen bonding. The 3 point bending test (INSTRON) shows that the strength of bleached fibres increases with the comparison of raw fibre. Samia S. Mir et al [46] characterized brown single coir fibre for manufacturing polymer composites reinforced with characterized fibres. Adhesion between the fibres and polymer is one of factors affecting the strength of manufactured composites. In order to increase the adhesion, the coir fibre was chemically treated separately in single stage (with $Cr_2(SO_4)_3 \bullet 12(H_2O)$) and double stages (with $CrSO_4$ and $NaHCO_3$).Both the raw and treated fibres were characterized by tensile testing, Fourier transform infrared (FTIR) spectroscopic analysis, scanning electron microscopic analysis.mechanical properties of characterized fibre in this analysis was found to be better than the raw fibre and that of the double treated even better. Scanning electron micrographs showed rougher surface in case of the raw coir fibre. The surface was found clean and smooth in case of the treated coir fibre.

3. Review Objectives

The present review focuses on the progress of coir fiber 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. The present review also focuses on the use of coir fiber as filler in composite material, extracted from a Coconut husk. The objective of the present study is to utilize the advantages offered by renewable resources for the development of composite materials based on coir fibers.

Conclusion

The present review has been undertaken, with an objective to explore the potential of the Coir fiber polymer composites and to study the mechanical properties of composites. The present review reports the use of Coir fibers, 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 Coir fibers have been extensively used in a wide variety of application, e.g., packaging, furnitures etc. The present contribution defines some selected works in the field of Coir fibers. The influence of the source of Coir fiber on the mechanical properties of bio composites was reported. Several natural fiber composites achieve the mechanical properties of glass fiber composites and they are already applied, e.g., in furniture industries etc. At present, the most important natural fibers are Jute, flax, bagasse and coir. The future of coir fiber composites appears to be bright.

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