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Natural Fibers Reinforced Polymer Composite Materials – A Review

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Abstract:

Natural fiber reinforced polymer composites are the substance in which natural fibers are employed to reinforced by means of polymer matrix so as to improve its mechanical properties. These are environmental friendly, cost effective natural fiber,eco-friendly, reduced cost and effortless manufacturing have encourage researchers global to try nearby available inexpensive fiber and to study their probability for reinforcement purposes and to what extent this natural fibers justify the essential specifications of excellent reinforced polymer composite for Industrial, Automotive, Aerospace,packaging, Medical and Structural applications. Latest trends in natural fiber development are genetic engineering. In composites,technology offer substantial opportunities for enhanced materials becauseof renewable resources with superior support for universal sustainability. In comparison with conventional composites, Natural fiber composites have ecological advantages and lesser density, thushave smarterapplications in various industry. Due to non-carcinogenic and bio-degradable nature of these composites, higher focus on Natural fibers is gained during present scenario.

Natural fibers need to be treat chemically to improve interfacial adhesion between fiber surface and polymer matrix. The chemically treated natural fibers show better progress in properties than untreated fibers. This can be recognized to the removal of waxy layer from the surface of natural fibers and thus making it rougher. Natural fiber reinforcements have contributed in improved impact toughness and fatigue strength. Many efforts have been made by researchers towards enhancing mechanical properties. This journal focuses up on properties of the natural fibre reinforced polymer composites along with its relevance.

Keywords: Chemical treatment, Mechanical Properties, Natural fiber, Polymer Matrix, Reinforcement.

I. Introduction:

A composite material structure is composed of two or more physically distinct phases whose combination produces comprehensive properties that are dissimilar from those of its constituents. Composites can be very significant because of its physically powerful and rigid, yet very light in weight, so ratios of strength to weight and stiffness to weight are several times stronger than steel or aluminum and also possible to achieve combinations of properties not attainable with metals, ceramics, or polymers alone[8].

Currently interest in Natural fiber reinforced polymer composites are growing rapidly due to its numerous advantages. These composites are more eco friendly and regularly used in various manufacturing applications worldwide such as in Automobile, Aerospace, Medical, Construction and Household Applications etc. In fiber reinforced polymer composites, the fibers can be either artificial fibers or natural fibers. The fibers derived from natural resources like plants are termed as Natural fibers. A great deal of research work has previously been made on the potential of the natural fibers as reinforcements for composites. Advantages of natural fibers over artificial fibers comprise low density, low cost, accessibility, recyclability and biodegradability [1].

The artificial Fiber Reinforced Polymer Composites own fashionable mechanical strength; they have some solemn drawbacks such as high cost, high density when it is compared with polymers, and reduced recycling and non biodegradable properties. For these reasons, past few years natural plant fibers reinforced polymer composites are more and more gaining attention as realistic alternative to artificial Fiber Reinforced Polymer Composites.

II. NATURAL FIBERS

In the advanced years, normal strands strengthened composites are treated as best material in various applications because of its beautiful properties [8]. The word characteristic infers a specific substance which exists normally and not fake. The word fiber is characterized as a hair-like or strand like structure which has high perspective proportion.

Common strands have a few significant favorable circumstances more noteworthy than the utilization of fake filaments. At present, numerous sorts of regular filaments have been researched as fortification in polymer framework including flax, hemp, jute straw, wood, rice husk, wheat, grain, oats, rye, stick (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm void organic product cluster, sisal, coir, hyacinth, pennywort, kapok, paper mulberry, raphia, banana fiber, pineapple leaf fiber and papyrus. The synthetic piece of fiber is cellulose, hemicelluloses, lignin, gelatin and waxy substances. The regular filaments are hydrophobic in nature and in this way are treated with reasonable synthetics to diminish the hydroxyl bunch in the strands. Compound treatment responds with hydroxyl gathering of the normal fiber and improves hydrophobic highlights and improves interfacial bond with polymer matrix [1].

Classification of Natural Fibre [2]

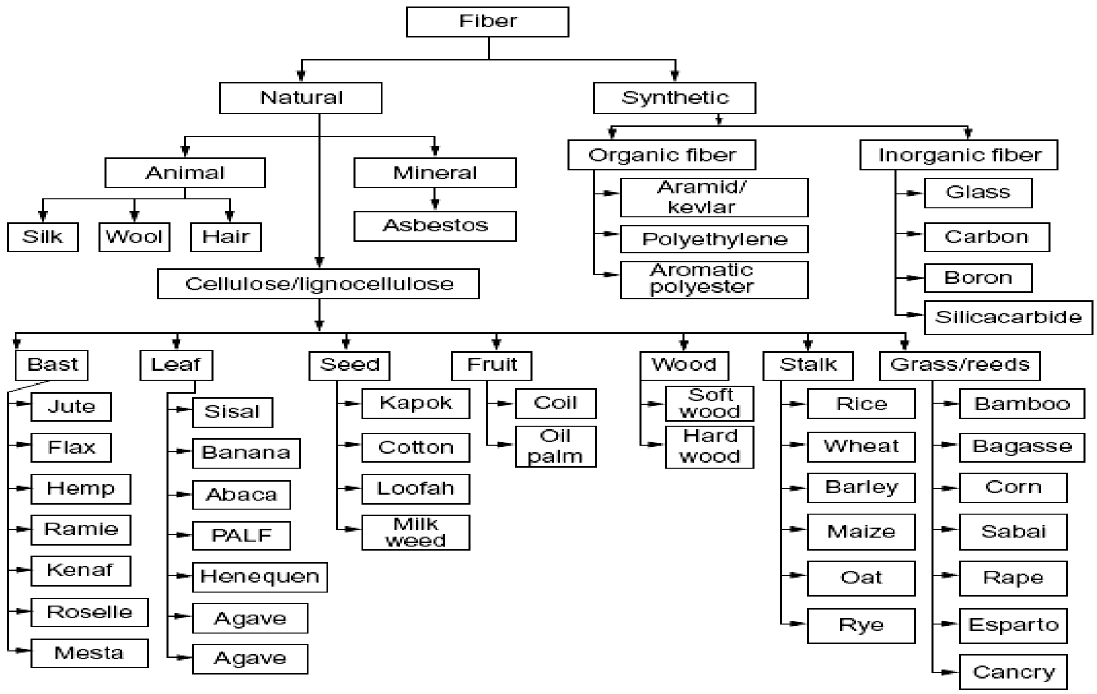

Figure.1. Natural fibers classifications [7]

Table 1. Provides information regarding natural fibers existing in the nature in different form [8].

Wood fiber	Stalk fiber	Fruit fiber	Seed fiber	Leaf fiber	Bast fiber
Hard wood	Bamboo	Coconut	Cotton	Sisal	Rattan
Soft wood	Wheat	Betel nut	Oil palm seed	Manila	Hemp
Saw dust	Rice		Kapok	Banana	Jute
	Grass		Alfalfa	Palm	Ramic
	Barley			Mengkuang	Banana
	Corn			Date palm	Flax
				Pineapple	Sugar cane
				Abaka	Kenaf
					Roselle

Table 2. Natural fibers reinforced with polymers

Thermoplastics		Thermosets	
Polymer	**Fibers**	**Resin**	**Fibers**
Polypropylene (PP)	Curua, coconut husks, hemp, jute, sisal, sugarcane bagasse	Polyester	Bamboo, banana, coconut, flax, pineapple, hemp
Polyethylene (PE)	Banana, rice husk, sugarcane bagasse	Polyurethane	Coconut, banana, curcua, sisal
High density PP	Banana, curcua, sisal, wood	Epoxy	Cotton, flax, hemp, jute, sisal, pineapple
Polystyrene (PS)	Coconut husks, sisal, sugarcane bagasse	Phenolic	Flax, sisal, jute, banana

Structure of a Natural Fiber [7].

Plants strands comprise of empty cellulose fibrils held together by the lignin as a cover in the hemicelluloses as a lattice, accordingly they are considered as composites. The cell mass of the plant fiber is inhomogeneous where every specific kind of types of plant has its own restrictive fiber qualities. Strands have an entangled structure comprised of different layers. The meager essential divider is encompassing an auxiliary divider all through cell development. The auxiliary divider, which comprises of three unique layers, the most significant layer is the center, since its thickness controls a definitive mechanical conduct of the fiber. The center layer is convoluted and comprises of helical cell small scale fibrils of somewhere in the range of 10 and 30 nm long. In extra detail, the miniaturized scale fibrils point, which is the edge between the pivot of the fiber and the smaller scale fibrils, has some extraordinary esteem that fluctuates from one fiber to any more. The nature of the strands (luxuriousness and deftness) is constrained by this miniaturized scale fibrils edge. The indistinguishable grid in the cell divider is extremely mind boggling. It comprises of hemicelluloses, gelatin, and lignin. The hemicelluloses molecule is hydrogen attached to cellulose and executes as solidifying grid among the cellulose miniaturized scale fibrils to construct the primary basic component of the fiber cell, which is known as the cellulose-hemicelluloses organize. The most significant objective of hydrophobic lignin and gelatin components is to raise the solidness of the cellulose/hemicelluloses component. A schematic structure of a characteristic fiber is represented in Figure.2.

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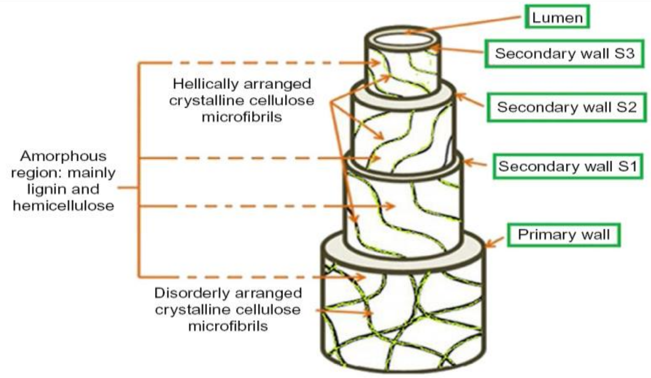

Figure.2. Schematic organization of a Natural Fiber

III. Fiber Orientation

The incomparable mechanical properties can ordinarily be acquired for composites when the fiber is adjusted parallel to the course of the down to earth load. Be that as it may, it is progressively mind boggling to get arrangement with normal strands than for nonstop counterfeit filaments. Some course of action is accomplished amid infusion forming, reliant on network consistency and shape plan. In any case, to get to higher degrees of fiber arrangement, long characteristic fiber can be checked and put physically in sheets preceding grid impregnation [3].

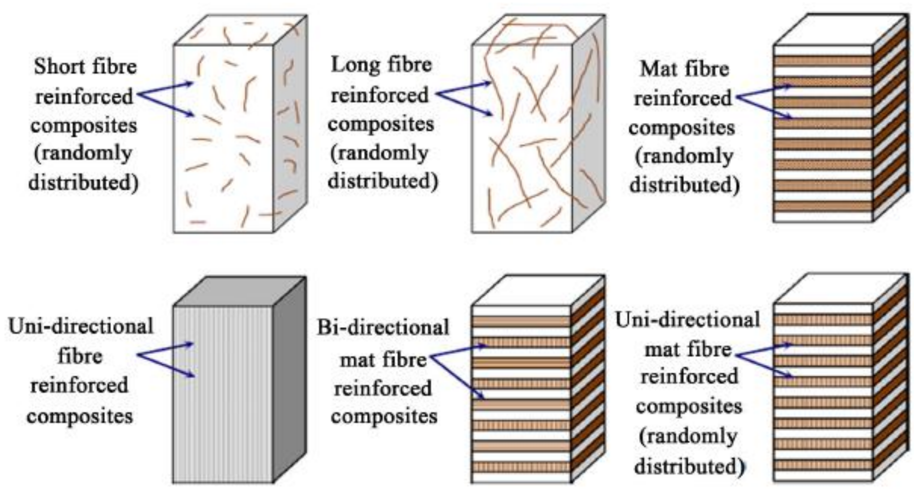

Figure.3. Different type of fiber orientation used for the laminate manufacturing[8].

IV. Different Surface Treatment of Natural Fibers and Use of Adhesion Promoters [6]

The principle trouble of normal filaments in fortification to composites is the diminished similarity among fiber and network because of the hydrophilic idea of strands and hydrophobic nature of polymer macromolecules. This is critical issue, since the simple expansion of natural– natural filaments to a polymer lattice may prompt poor mechanical properties in contrast with the clean polymer. In this manner, normal fiber alteration is considered in changing the fiber surface properties to improve their attachment with unique networks.

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The primary procedure was condensed as pursues

Salt Treatment: It is one of the dominant part utilized compound techniques for characteristic strands when used to strengthen thermoplastics and thermosetting. It expels a specific measure of Lignin, wax and oils wrapper the outside surface of the fiber cell divider. The significant change accomplished with antacid treatment is the interruption of the hydrogen holding in the system structure, along these lines expands the surface unpleasantness it is commonly performed on short strands, by warming at approx. 800ºC in 10% NaOH fluid answer for around 3 to 4 hrs next wash and drying in ventilate broiler. It permits exasperating fiber bunches and getting littler and improved quality filaments. It ought to likewise improve fiber wetting.

Acetylation: In this strategy for adjusting the outside of characteristic filaments and making them further hydrophobic. It includes the presentation of an acetyl valuable gathering into a characteristic compound. The primary idea of acetylating is to coat the OH gatherings of strands which are responsible for their hydrophilic quality with particles that have an increasingly hydrophobic nature. In acetylating the strands are normally inundated in chilly acidic corrosive for 1 hr, at that point drenched in a blend of acidic anhydride and few drops of concentrated sulphuric corrosive for couple of min, next filtrated, washed and dried out in ventilated stove.

Benzylation: In this technique the filaments are submerged in 10% NaOH and after that mixed with benzoyl chloride for 1 hr, filtrated, wash and dried, at that point drenched in ethanol for 1 hr, flushed and dried in stove. This strategy diminishes the hydrophilicity of the strands.

Permanganate Treatment: In this strategy the strands are inundated in an answer of KMNO4 in CH3)2CO (regular focus may run somewhere in the range of 0.005 and 0.205%) for 1 min, at that point tapped and dried. Examination demonstrates a diminished hydrophilic condition of the strands upon play out this treatment.

Silane Treatment: In this technique the strands are drenched in a 3:2 liquor water arrangement containing a silane based bond advertiser for 2 hours at pH $\approx$ 4, washed in water and stove dried. Silanes ought to respond with the hydroxyl gatherings of the strands and improve their outside quality.

Peroxide Treatment: In this strategy the filaments are drenched in an answer of dicumyl (or benzoyl) peroxide in CH3)2CO for about thirty minutes, at that point emptied and dried. Late examinations have painted critical upgrades in the mechanical properties.

Catalyst Treatment: The utilization of compounds innovation is reasonable progressively impressive for the preparing of common strands. By and by, the utilization of chemicals in the field of material and common fiber adjustment are likewise quickly developing. A fundamental purpose behind execution of this innovation is earth neighborly. The responses catalyzed are exact and have centered introduction.

Isocyanate Treatment: In this treatment Isocyanate bunch can respond with the hydroxyl bunches on fiber surface, hence improving the interface grip with polymer network. The treatment is ordinarily execution with Isocyanate mixes at in the middle of temperature (around 500ºC) for roughly 1 h.

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Plasma Treatment: It is another physical treatment technique and is, like crown treatment. The property of plasma is abused by the procedure to initiate changes on the outside of a material. An assortment of surface adjustment can be accomplished relying upon the sort and nature of the gases utilized. Receptive free radicals and gatherings can be created, the surface vitality can be improved or lessening and surface cross connecting can be presented.

Esterification: Treatment with stearic corrosive, the corrosive is added to an ethyl liquor arrangement, up to 10% of the complete load of the filaments to be dealt with. The acquire arrangement is in this manner added drop insightful to the filaments, which are then dried in stove.

Crown Treatment: It is a standout amongst the most energizing physical treatment systems for surface oxidation actuation. This strategy changes the surface vitality of the cellulose filaments. Crown release treatment on cellulose fiber and hydrophilic network was observed to be useful for the improvement of the compatibilization between hydrophilic strands and a hydrophobic framework.

V. Polymer Matrix Materials

They are generally classified into two categories as follows [1]:-

Thermoplastic Polymers

These are linear and branched series polymers formed by addition polymerization. Thermoplastic can be formed at superior temperatures, cooled and remelted and transformed into different shapes without altering the properties of polymer. However, the heat used to melt and remelt the thermoplastic must be carefully controlled or material will decompose. Polystyrene, Polypropylene and Polyethylene are frequently used thermoplastic resin for natural fiber reinforced composite [1].

Thermosetting Polymers

These are cross-linked polymers, created by strengthening polymerization. These polymers become permanently hard when heat is applied and do not softened or reshaped upon subsequent heating, due to the loss of part of the molecule (the byproduct of the reaction) during the curing process. Once cured, if more heat is applied to a thermosetting material, it will char, burn or decompose. Thermosetting polymers are commonly harder and stronger than thermoplastics and contain better dimensional solidity. Usual thermosetting polymers include phenolics, aminos, polyesters, epoxies and alkyds [1].

Table 3. Major polymers used as matrix for composites[17]

Thermoplastic Polymers	Thermosetting Polymers
Nylon	Phenolic
Cellulose acetate	Epoxy
Polystyrene (PS)	Polyester
Polypropylene (PP)	Polymide
Polyethylene (PE)	Polyurethane
Polycarbonate (PC)	
Polyvinyl chloride (PVC)	
Polyether–ether ketone (PEEK)	
Acrylonitrille-butadiene-styrene (ABS)	

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Table 4. Some major properties of thermoplastics matrix materials [17]

Thermoplastics	Density (g/cm3)	Tensile modulus (GPa)	Tensile strength (Mpa)	Melting temperature (°C)
Polypropylene (PP)	0.90–0.91	1.1–1.6	20–40	175
Polyethylene (PE)	0.91–0.95	0.3–0.5	25–45	115
Polyvinyl chloride (PVC)	1.38	3.0	53	212
Polystyrene (PS)	1.04–1.05	2.5–3.5	35–60	240
High density PP	0.94–0.97	0.5–1.1	30–40	137

Table 5. Some major properties of thermosetting matrix[17]

Thermosets	Density (g/cm3)	Tensile modulus (GPa)	Tensile strength (Mpa)	Elongation at break (%)	Compression strength (Mpa)
Polyester	1.0–1.5	2.0–4.5	40–90	< 2.6	90–250
Epoxy	1.1–1.6	3.0–6.0	28–100	1–6	100–200
Vinyl ester	1.2–1.4	3.1–3.8	69–86	4–7	86
Phenolic	1.29	2.8–4.8	35–62	1.5–2.0	210–360

The interface between the natural fiber and polymer resin

The holding interfacial grip between the common fiber and the polymer grid is influenced by mechanical interlocking, appealing powers and synthetic bonds between the normal fiber and the rein. Regular filaments have hydroxyl gatherings and hydrogen bonds can thusly be framed to the outside of the characteristic fiber. The bond quality in regular fiber strengthened composite is diminished by the ingestion of dampness. The hydrophilic filaments assimilate the dampness from nature and hydrogen bonds are made between hydroxyl gathering of the cellulose particle and the consumed water. Dampness retention additionally influences the dimensional strength of common fiber. This outcomes to poor grip among pitch and framework which causes debonding. Drying fiber before preparing is exceptionally basic since it improves the mechanical properties of the composites [1].

Table 6. Typical characteristics and applications of some polymer Materials [17]

Thermoplastics		
Thermoplastics	**Uniqueness**	**Applications**
Acrylics	Special resistance to long-term exposure to sunlight and good light transmission	Swimming pools, skylights, sinks and washbasins and on tail lights on automobiles
Acrylonitrille	Stupendous impact strength and high	Appliances, automotive parts,

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Butadiene-Styrene (ABS)	mechanical strength	telephone components, shower heads, door handles and automotive front grilles
Nylon	High stability and adaptability	Automotive parts, electrical and electronic applications, and packaging
Polycarbonate	Excellent electrical insulating characteristics, strong, and rigid	Electrical and electronic applications
Polyethylene	Rigid and moisture resistant	Packaging films, house wares, toys, containers, pipes, gasoline tanks, andcoatings
Polypropylene	Light-weight material and good insulation properties	Packaging and foodservice products, automotive parts, radio and TV housings
Polyamide-Imide	Outstanding mechanical, thermal and chemical resistant properties	Aerospace, heavy equipment and automotive
Thermosets		
Thermosets	**Uniqueness**	**Applications**
Epoxy	Virtually no post-mold shrinkage, resistance to high impact and high temperatures, chemical resistant and fungus resistant	Adhesives, protective coatings in appliances, industrial equipment and aircraft components
Phenolic	Excellent dielectric strength, huge mechanical strength and dimensional stability, resistant to high heat, wear resistant, low moisture absorption	Adhesives, casting resins, laminating resins, electrical and electronic Applications
Polyimides	Recognized for thermal stability, good chemical resistance, excellent mechanical properties, exhibit very low creep and high tensile strength, inherently resistant to flame combustion	Electronics, medical tubing, adhesives, gears, covers, bushings, piston rings, and valve seats
Urea-Formaldehyde	Extremely hard, scratch-resistant material with excellent chemical resistance, electrical qualities and high temperature resistance	Electrical and electronic products, decorative products, laminates, and chemically resistant coatings

VI Conclusions

The extensive research work has been occurring in the field of polymers. Enhancements have happened in the improvement of composites by choosing matrices and fibers. This outline given the spotlights on research did for development of the mechanical properties like quality,strength, stiffness and impact strength including effect quality including the impact of water retention and enduring on these properties. The consolidation of polymers in the composites has advantage over the characteristic composites. The polymer matrix composites have several advantages, such as low cost, low densityand lesser abrasiveness. The work is as yet expected to investigate the degree and restrictions of these materials.So the research must focus on the advancement of such materials with balance of structureand property of composites having lower cost and manufacturability. One huge limitationwould be many of the polymer matrix materials are non biodegradable and best case scenario one could accomplish somewhat degradable composites.

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