Effect of moisture absorption and chemical treatment on the properties of natural fiber reinforced polymer composites: An assessment

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Abstract : In recent years, Hybrid composites were advanced through the usage of different types, shapes, and sizes of reinforcement. The fillers and matrix used in these composites were chosen for their synergistic qualities.. Natural fibres, on the other hand, have a number of drawbacks, including limited dimensional stability, low thermal stability, and high moisture absorption, severely limit their potential for use as polymer reinforcement. Natural fibres have a low resistance to water absorption, which is one of their biggest drawbacks. This has negative consequences for fibre mechanical characteristics and dimensional stability, and leads to embrittlement over time, which is linked to the hydrolysis of the macromolecular skeleton. As a result, it's critical to investigate the water absorption behaviour in depth in order to determine not only the potential implications of the absorbed water, but also how this water absorption might be reduced in some way. They are biodegradable, do not contaminate the environment in any manner, have high mechanical, thermal, and tribological capabilities, and have good tensile strength and durability. Tensile strength, impact strength, compressive strength, and so on are examples of mechanical qualities, while tribological properties describe the material's wear and tear or abrasive properties. Natural fibres are long-lasting, although their qualities in the presence of moisture vary depending on the medium and procedure used to extract them. Different natural fibres absorb moisture at different rates and behave differently once they've absorbed it. The purpose of this research is to look at how moisture absorption and chemical treatment affect the characteristics of natural fibre reinforced polymer composites.
***IndexTerms* - Composite Material , Natural Fiber, chemical tretment, alkaline treatment.**

I. Introduction

In today's world, hybrid polymer composites are the newest form of materials whose property can be enhanced using different materials with different properties for different applications [1], When more than one reinforcement is in a matrix, hybrid composites are obtained in a way that the properties are increased of individual reinforcement [2] or Hybrid composite are the composites which have more than one fibers in a single matrix [3].

The matrix in composites is used for the following:

- Improves composite impact and fracture resistance.
- Carry interlaminar shear.
- To keep the fibres in the proper position and orientation
- To connect the fibres and switch the applied force between them.
- To guard the reinforcement from the effects of the environment, such as humidity, temperature, mechanical, and chemical degradation, this is typically caused by abrasion.
- Enhances the transverse properties of composite.

The following are the matrix's requirements or desirable features that are important for a composite:

- Strength at high temperature
- Must be elastic to switch load to fiber
- Low coefficient of thermal expansion
- Better chemical resistance
- Should be easily processable into final composite shape
- Dimensional stability
- Reduced moisture absorption
- Low shrinkage
- Excellent flow characteristics so that it penetrates the fiber bundles completely and get rid of voids at some stage in the compacting system

The following elements influence the improvement of mechanical and thermal properties of manufactured polymer composites:

- Manufacturing method/techniques
- Shape of the fiber
- Aspect ratio and orientation of fiber
- Percentage of fibers in the composites
- Type of fillers (if used)
- Type of matrix
- Type of fiber

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The epoxy resin and nano particle blending directly provides a convenient rate for inorganic hybrid compositors to form epoxy resin. As the content of inorganic components boosts, the thermal stabilities of the hybrid composites also increases, Liu.et al "investigated the thermal stability of epoxy silica hybrid materials through thermogravimetric analysis" [4]. The addition of nano Al_2O_3 and Nano SiC particles to the epoxy resin also improves the thermal stability [5].

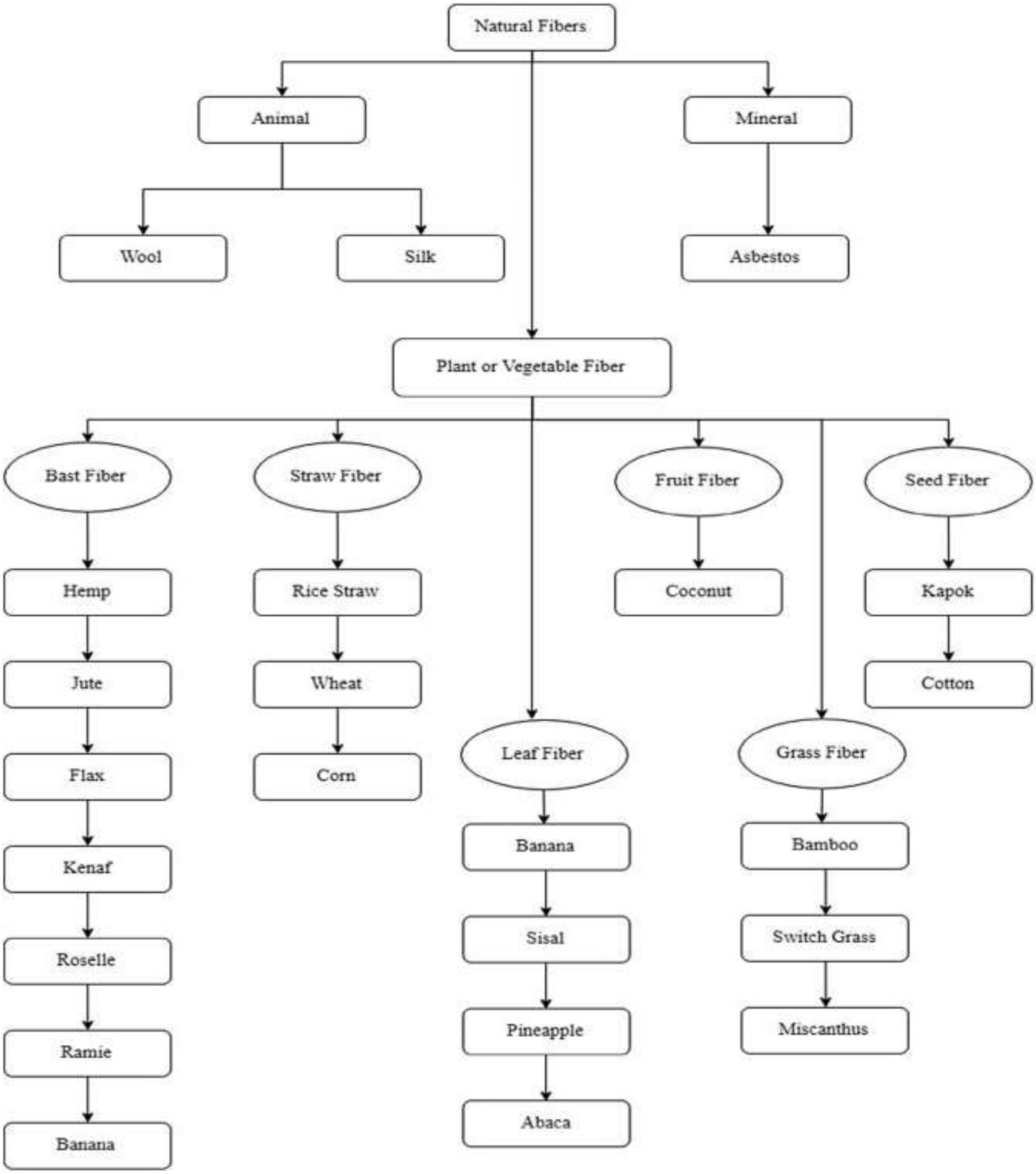

Fig. 2. Classification of Natural Fibers.

Physical and Mechanical Properties of Natural Fibers.

Type of fiber	Density (g/cm2)	Specific gravity	Specific strength (MPa)	Tensile strength (MPa	Specific modulus (GPa)	Elongation (%)	Youngs modulus (GPa)
Bamboo	1.1	0.4–0.8	454	500–575	50–67.9	1.9–3.2	27–40
Bagasse	1.5	1.4–1.5	–	170–350	3.6–4.1	6.3–7.9	5.1–6.2
Wheat	1.45	–	–	–	–	–	–
Betelnut	0.2–0.4	1.3–1.4	–	120–166	1.0–1.9	22–24	1.3–2.6
Banana	1.35	1.1–1.2	444	711–789	3.6–27.3	2.4–3.5	4.0–32.7
Coir	1.25	1.2–1.4	146	170–230	2.5–5.0	14–30	3.0–7.0
Abacca	1.5	–	–	980	–	–	–
Sisal	1.33	1.3	366–441	400–700	6.5–30.8	1.9–15	8.5–40
Jute	1.46	1.3–1.5	269–548	385–850	6.9–20.7	1.4–2.1	9–31
Kenaf	1.2	1.3	641	223–1191	10–42.9	1.6–4.3	11–60
Remie	1.5	1.6	147–625	200–1000	27–81	1.5–4	41–130
Hemp	1.48	1.5	372–608	550–900	–	0.8–3	–
Flax	1.4	1.5	535–1000	340–1600	16.7–54	1.1–3.3	25–81

Treatment through chemical agents

Natural fibers inherently own excessive quantity moisture and greater water absorption capability. This finally ends up in terrible interface among the matrix and reinforcement. To convert the fibers into hydrophobic from hydrophilic nature, chemical treatment of fibers is necessary.There are many chemical treatments available in that best chemical treatment is finding out based upon the environmental aspects and cost factor. "A certain amount of lignin, hemi-cellulose, wax and oils that cover the exterior surface of the fiber cell wall were extracted by alkali treatment". As a result, the fiber surface is rougher for stronger fiber interlocking for mattress penetration and a greater fiber-matrix contact area [6]. Alkali treatment is one of the most common chemical treatments used, which enhances the mechanical property of fiber and very efficient surface modification and of low cost [7].

Mechanical properties of natural fibres after various chemical treatments:-

S. No	Treated Fiber	Chemical Treatments Applied	Effect in Mechanical Properties	Ref. No
I.	Fiber of Sisal	Untreated Vs treated fibers	When comparing treated fiber composites to untreated fiber composites, dynamic mechanical properties such as storage modulus have been enhanced.	17
II.	Vetiver Fiber	5% Alkaline Treatment	Raw vetiver fiber composite had a maximum tensile strength of 11.9 MPa, while chemically treated fiber composite had a maximum tensile strength of 13.59 MPa.	16
III. :	Fibers of Pineapple Leaf	Silane Treatment & Alkaline Treatment	For treatment through alkaline, the thermal and mechanical properties were determined to be excellent.	15
IV.	Doum Fibers	Alkaline Treatment	Flexural modulus and Young's modulus all improved significantly after alkaline treatment.	14
V.	Different Fibers	Alkaline Treatment	The most successful way for improving interfacial bonding between fiber and matrix was discovered to be alkaline treatment, while other treatment methods had little impact or reduced fiber strength.	13
VI.	Fiber of Flax	Alkaline Treatment	The flax/epoxy composites' young's modulus and tensile strength increased as fiber shrinkage was reduced.	12
VII.	Fiber of Ramie	15% Alkaline Treatment	The tensile strength of treated ramie fiber has increased by 4 to 18 percent compared to untreated ramie fiber.	11

VIII.	Flax	Maleic Anhydride, Mercerization	When compared to untreated and mercerized fiber composites, MAH-PP treated flax/PP composites had a 50% higher tensile strength.	10
IX.	fiber of Aspen	Alkaline Treatment	The tensile strength has been advanced	9
X.	Coir	20 percent alkali treatment followed by 50 percent ethylene dimethyl acrylate grafting	After the fibre was treated, the composites' mechanical characteristics improved dramatically.	8

Applications of hybrid composite

Hybrid polymer composites can be applicable in components of automobiles like interior paneling, front and rear bumper, dashboard, seat belt, aircraft brake pedals, soundproofing material and Furniture [18].

Table No. 2: Important application of hybrid composites [19].

Electrical and electronic appliances	Packaging, switches, Casting, pipes, etc.
Aerospace industries	Propellers and helicopter fan blades, Wings, Tails, etc.
Civil industry	wall, roof tiles, floor, Partition boards panels, window and door frames, and false ceiling, etc.
Transportation	Gears, railway coach interior, Automobile, etc.
Daily used substances	helmets, suitcases, baseball bats, ice skating boards, bicycle frames, lampshades, etc.
Furniture	Table, bath units, Chair, hanger , shower, handle, door panel etc.
Storage tank	Grain storage silos, biogas container, dryer, Post-boxes, etc.
Marine and military application	Various applications.

Conclusion

When compared to synthetic composites, NFPC outperformed them due to its low density, low cost, and environmental friendliness. As a result, natural fiber composites have numerous advantages in commercial and engineering applications. Natural fibers, on the other hand, have lower strength than synthetic composites, but when combined with artificial composites, provide tremendous strength and less environmental impact.

The Following conclusions can also be summarized:

- The inclusion of a coupling agent can increase the adhesion quality between polymer matrix and cellulosic materials by reducing interfacial gaps and blocking hydrophilic groups.
- The addition of the coupling agent was shown to be very effective in increasing the adhesive nature between natural composite fibers, and the hybrid composites showed an increase in young's modulus due to homogeneous dispersion or distribution of both fillers into the polymer matrix.
- The thermal analysis also shows that the addition of a coupling agent gives the better thermal stability to composites.
- Observation has revealed that the alkaline treatment is the most acceptable approach of chemical modification for natural fibers. The qualities of natural fiber, composite hybridization, chemical processing methods, and natural fibre applications in many fields were all investigated in the current study. This gives a clear picture of how natural fibers are processed, the characteristics of specific fibers such as sisal, jute, and hemp, and how they are used in various sectors dependent on the properties of the natural fibre considered.

- Alkali treatment, bleaching, peroxide treatment, benzoylation, acetylation, vinyl grafting, and multi-coupling agent treatment can improve the degree of interfacial adhesive nature between the matrix and the natural fibers, as well as the mechanical qualities of the fibers.

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