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A Review on Natural Fiber Reinforced Composites and its Applications.

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Abstract: ***Natural fibers are gaining numerous attention due to their ecofriendly nature and sustainability. The problem of global warming and environmental imbalance is being faced throughout the world which needs to be resolved. The aim of this review paper is to give a comprehensive review about the natural fiber reinforced composites and its applications. It also explains about the various surface treatments and which are applied to the natural fibers and their effects on these fibers. The properties of natural fibers vary on various factor such as fiber type, fiber size, orientation, and its structure. Being various advantages of natural fiber reinforced composites there are some disadvantages also which are high moisture absorption, lower mechanical properties and lower fire resistance which limits the applications of natural fiber reinforced composites.***
Keywords: Natural fibers, composite materials, properties, applications.

I. INTRODUCTION

Natural fibers in simple words are the fibers which are not man-made or synthetic but are sourced from the plants and animals. In the last decade natural fibers have gained attention both from the renewable as well as nonrenewable resources such as hemp, kenaf, sisal, flax, and jute. The plant fibers are basically classifieds into three categories i.e., bast fiber, seed fiber, leaf fiber and core fibers. Bast fibers are flax, kenaf, jute and hemp while seed fibers are coir and cotton. Leaf fiber contains sisal, pineapple and abaca. While core fibers are kenaf, hemp and jute. Natural fibers have good properties as compare to synthetic fibers as well as they are environment friendly. Instead of good properties they have flexibility during processing, minimal health hazards and biodegradability [2]. On the other hand, natural fibers have notable demerits. natural fibers consist of cellulose, hemicellulose, lignin, pectin and waxy substances which allows the absorption of moisture from the environment which causes weak adhesion between the matrix and reinforcement. For the proper adhesion of matrix and reinforcement, fiber modification is very important and for that specific treatment of fibers are required [3].

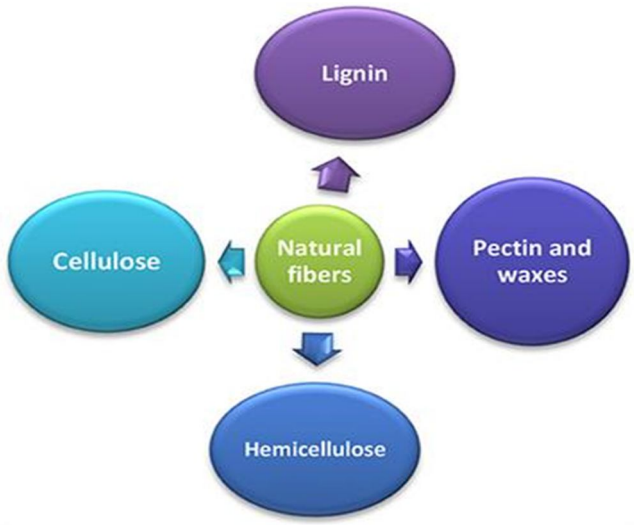

Fig 1 classifications of natural fibers constituents

Fiber modification results in the reduction of moisture absorption from the environment which enhances the incompatibility between the natural fiber and matrix [5]. There are various applications of natural fibers in the engineering fields. Many industries are using natural fibers as an alternate to synthetic fibers in different automotive applications such as ford, Volkswagen, BMW and Audi. Besides the automobile industry, natural fiber reinforced composites are also having applications in sports, aerospace, panels, window frames and bicycle frames [6].

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II. NATURAL FIBER REINFORCED POLYMER COMPOSITES

Natural fibers are categorized based on their origin such as plant fibers, animal fibers and mineral fibers. The major difference between the plant fibers and animal fibers is that the former consists of cellulose as major constituent and later consists of protein as major constituent. Plant fiber constituents include cellulose (60%-80%), Hemi-cellulose and lignin (5-20%), while rest constituents are pectin, waxes, moisture (up to 20%) and water-soluble organic components, which are found to vary widely depending on their origin and type. Cellulose is the major component of natural fiber which have strength and stiffness of >2Gpa and 138Gpa, respectively [8]. Fibers which have high cellulose content are found to provide high reinforcing effect in polymer composites. Fibers which are obtained from the bast, tend to possess higher cellulose content. Other constituents of natural fibers such as hemi-cellulose and pectin dictate other properties such as water absorption, wet strength, swelling and integration of fiber bundle.

The increasing cost of synthetic fibers and the environmental concerns have emphasized over the use of natural fiber reinforced composites because they are economical, abundantly available, recyclable, biodegradable and possess high mechanical strength. Natural fibers like bamboo, jute, banana, coir, kenaf etc. are being used as reinforcements in polymeric matrixes. Natural fibers properties are different from each other due to various kinds of fibers, their sources and their moisture conditions [9]. Natural fiber composites performances depend on several factors like structure, physical and chemical properties, mechanical compositions and the interaction between fiber and matrix. Although every product has its own merits and demerits, so the drawbacks of natural fiber reinforced composites is their weak interaction between the fiber and matrix, which leads to poor stress transfer during the interaction between the fiber and matrix [11]. To overcome these problems, chemical treatments must be done of the natural fibers so that it reacts on fiber surface structure and alter the fiber composition.

Fiber	Cellulose (%)	Hemicelulose (%)	Lignin (%)	Waxes (%)
Sugarcane bagasse	45	30	24	1
Bamboo	26–43	30	21–31	-
Flax	71	18.6–20.6	22	1.5
Kenaf	72	20.3	9	-
Jute	61–71	14–20	12–13	0.5
Hemp	68	15	10	0.8
Ramie	68.6–76.2	13–16	0.6–0.7	0.3
Sisal	65	12	9.9	2
Coir	32–43	0.15–0.25	40–45	-
Pineapple leaf fiber	81	-	12.7	-
Curaua	73.6	9.9	7.5	-

Table 1: Chemical composition of common natural fibers [4]

Natural fibers are classified depending on their origins into the following groups which are plant, animals and minerals. Plant fibers are one of the commonly used and most analyzed by the researchers. This is due to the fact that they have short growth period, renewability and easy availability. A number of natural fibers are available which are being used like jute, kenaf, hemp, sisal and abaca. These fibers are mainly composed of cellulose, hemi-cellulose, lignin, pectin and waxes [20]. Animal fibers are wool, hair and silk but these are not used commonly. The natural fibers have a number of advantages over synthetic fibers i.e., low density, low cost, easy availability, low carbon footprint and are easily biodegradable.

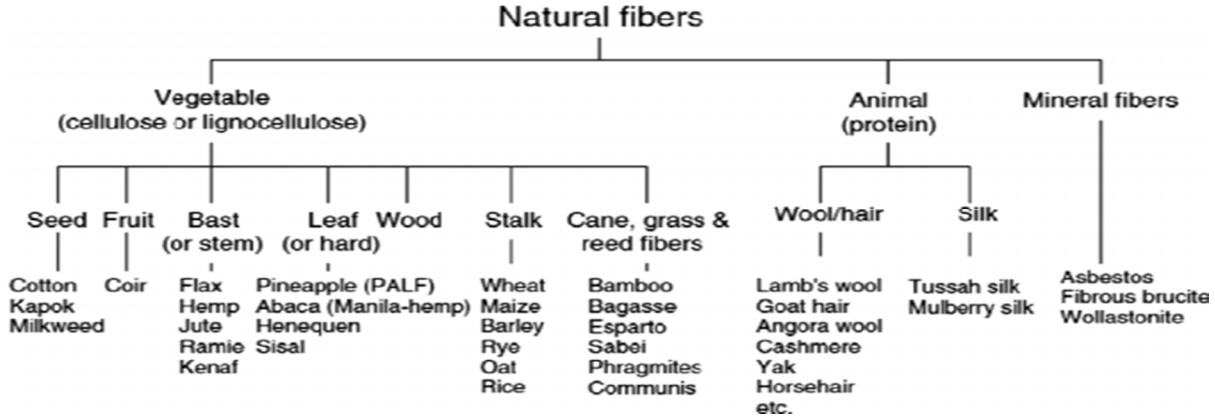

Fig 2 classifications of natural fibers

Usually, several treatments are required to overcome the limitations of natural fiber composites to improve fiber matrix interface adhesion which are named as coupling agents and heat treatments, water repellent chemicals, topological properties and water absorption index of fibers. By the literature review it came to know that cotton is one of the natural fibers with higher number of publications in the research community, followed by pineapple and bamboo [16]. Fibers like flax, hemp, jute and coir receives higher attention of the research community. Recently, the popularity of natural fibers is increasing among the research community due to their renewability, sustainability and biodegradability.

Fiber	Description
Coir	coir is one of the most durable and attractive natural fiber which is easily available and free from chemical treatments.
Flax	Flax fibers consist of low density, high strength and stiffness. They also have good tensile strength.
kenaf	Kenaf fiber is known for its high mechanical properties and have low density.
Jute	Jute fiber is one of the conventional fibers which is being used for its high strength to weight ratio and good insulation properties.
Sisal	The cultivation time of sisal is very short and it has high tensile intensity, salt water resistance and acid and alkali resistance.
Bamboo	Bamboo is one of the fastest growing plants having high strength to weight ratio, requires less water, no use of pesticides and light and stronger.
Abaca	Abaca looks like banana plant but its fruit is not for human consumption. It is grown only for the fiber cultivation.

Table 2 characteristics of natural fibers [17][30][31]

III. APPLICATIONS

Several industries such as construction, automotive, energy and aerospace, automobile are using natural fiber composites to make products which are environment friendly and reduce the dependence on the fossil fuels. Importance of raw materials is being increasing from renewable resources due to its biodegradability and recyclability which causes the transformation from the petroleum-based synthetics to natural fibers in automobile industry [17]. One of the main reasons for the use of natural fiber composites is its light weight and are environmentally friendly. Studies shows that natural fiber composites play an important role in weight reduction by 30% and cost reduction by 20% of and automobile part. Natural fiber composites also play important role in lower fuel consumption, good recycling possibilities and waste disposal. Natural fiber composites are mainly used for the interior parts such as dash boards, door panels, seat cushions and cabin linings whereas for the exterior parts the applications of natural fibers are limited. Besides various applications of natural fiber composites in automobile industry there are various additional fields of applications like medial, healthcare, pulp and paper, bioenergy and biofuels [38]. The lower weight and cost of natural fibers are the reasons for the use of these fibers in these applications. There is a vast are of its applications involving panels, boxes, casing and other type supporting and packaging objects [38]. Kenaf fibers are basically used in the inner door panel and mobile phone casings. While hemp, jute and kenaf are used in shipping and storage containers, underbody shields for car and trucks, workshop panels, for

offices and home furnishing. Coir fibers are used in the containers, boxes, trays and packaging, cotton fibers are used in the soundproofing, trunk panel and insulation. While coconut fiber is used in seat bottoms, back cushions, interior trim and seat surfaces. Flax fibers are used in seatbacks, covers, rear parcel shelves and floor panels. various types of natural fibers which are being used in the automobile sector in the manufacturing of various components of automobile. Some of the automobile manufacturer which are using natural fiber composites for the manufacturing of various components of the automobiles are shown below in the table-

Manufacturer	Model	NFC composite parts
Audi	A2, A3, A4, Avant, A6	Seat backs, side and back door panel, boot lining, hat track, and spare tire lining
BMW	3, 5, and 7 series and others	Door panels, headliner panel, noise insulation panels, seat backs, molded foot and well linings
Daimler/Chrysler	A,C, E, and S Class Evo Bus (exterior)	Door panel, windshield, dash board, business table, and pillar cover panel
FORD	Mondeo CD 162, FOCUS	Door panles, B-Pillar, and boot liner
Mercedes-Benz	Trucks	Internal engine cover, engine insulation, sun visor, interior insulation, bumper, wheel box and roof cover
Toyota	Brevis, Harrier, Celsior, RAUM	Door panels, seat backs, and spare tire cover
Volkswagen	Golf, Passat, Variant, Bora, Fox, Polo	Door panels, seat backs, boot liner, and boot lid finish panel
Volvo	C70, V70	Seat padding, natural foams, and cargo floor tray.

Table 3 various automobile companies using natural fiber composite parts (google)

IV. CONCLUSIONS

Natural fiber reinforced composites have low density, low cost, easy availability, as compare to the synthetic composites which is the prime objective of using these composites in in commercial applications like building and construction, automobile etc. the problem of environment pollution may be avoided by using the green composites which will put a beneficial effect on the society by reducing the effect of green house gases. This paper evaluates characteristics and applications of natural fiber composites. The physical and mechanical properties may be enhanced by proper modifications or chemical treatments. Chemical treatments play an important role in the reduction of absorption of moisture by the natural fiber composites.

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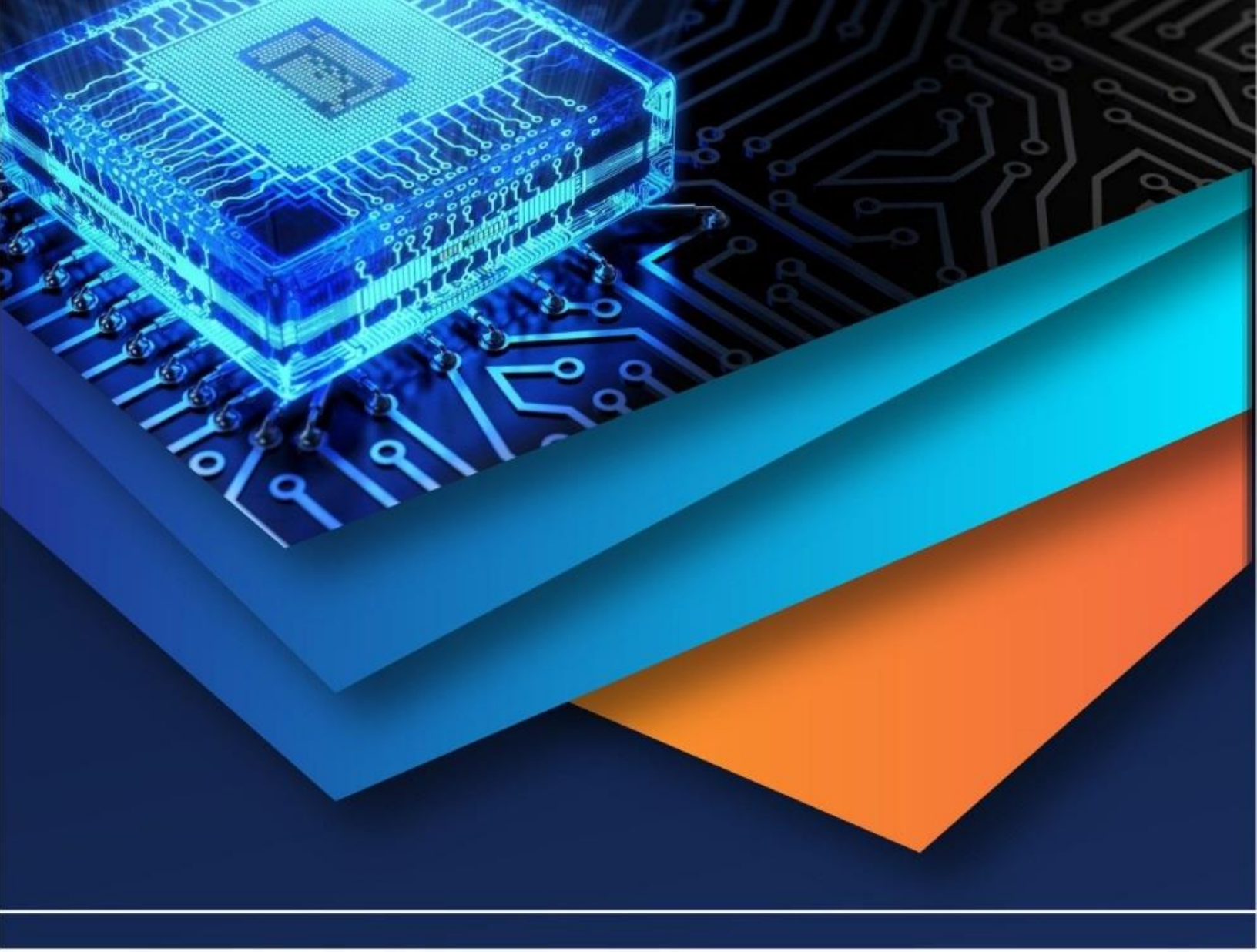

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