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## A Review on Natural Fibre Polymer Composite

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**ABSTRACT:** Recently natural fibre polymer composite have been a topic for researchers and has shown rapid growth in field of research and innovation. This review focuses on the benefits of using natural fibre as a reinforcement in polymer composite. Chemical treatment of natural fibres is also studied in order to understand its effect on different properties of fibre such as triboology, relaxation behaviour, flame retardancy, energy absorption, water absorption, viscoelastic behaviour. Also this review tells about various advantages and limitations of using natural fibre as reinforcement.

**KEYWORDS:** Natural fibre, Chemical treatment, Polymer composite

### I. INTRODUCTION

In the modern period composites, plastics, ceramics have emerged as widely used material finding its use in various sectors of manufacturing. The Natural Fibre as a reinforcement for the composite material has been found as a good alternative to glass reinforced composite and metals and in various engineering applications. Mostly these natural fibres are used to reinforce the polymer material forming natural fibre polymer composites. Natural fibres are light weight, renewable, non-abrasive, non-toxic, inexpensive and have low density [1]. These fibres are environment friendly and have good sustainability. They possess good mechanical properties like impact, tensile, and flexural strength. Due to these properties of the natural fibre the researchers are very much attracted to it and use them as reinforcement for polymer for the natural fibre polymer composites. The widely used natural fibres are jute, hemp, coir, sisal, banana fibre etc. Natural fibre polymer composites are finding applications in automobile industry, space crafts and for several other engineering applications [2].

Plants producing natural fibres are divided in primary and secondary according to their utilisation. Primary plants are grown basically for their fibres while in the case of secondary plants the fibres are extracted from the waste product. Countries like Malaysia, South-East Asia and Indonesia are the largest producers of palm oil and therefore produce large quantity of empty fruit bunch cellulose fibres which is a waste product [1]. Instead of disposing it they convert it as a reinforcement fibre material. Natural fibres are widely used material for reinforcement due to its advantageous properties. Despite the various benefits of natural fibres, they do have some drawbacks such as high moisture absorption, poor wettability and incapability of mixing with some of the polymeric matrices. Due to hydrophilic property of natural fibre it absorbs moisture due to which the mechanical properties such as flexural modulus, flexural strength and fracture toughness are adversely affected. To overcome this drawback chemical treatment of fibre is done which improves the adhesiveness and reduces the moisture absorption [3].

### II. CLASSIFICATION OF NATURAL FIBRES

Natural fibres are grouped into two types: animal fibres and plant fibres. Plant fibres are divided into primary and secondary according to their uses. Plant fibre consist of cellulose. Basically plant fibres are of six types: wood pulp, straw fibres, grass fibres, fruit fibres, leaf fibres and bast fibres. Natural fibres are used for many applications.

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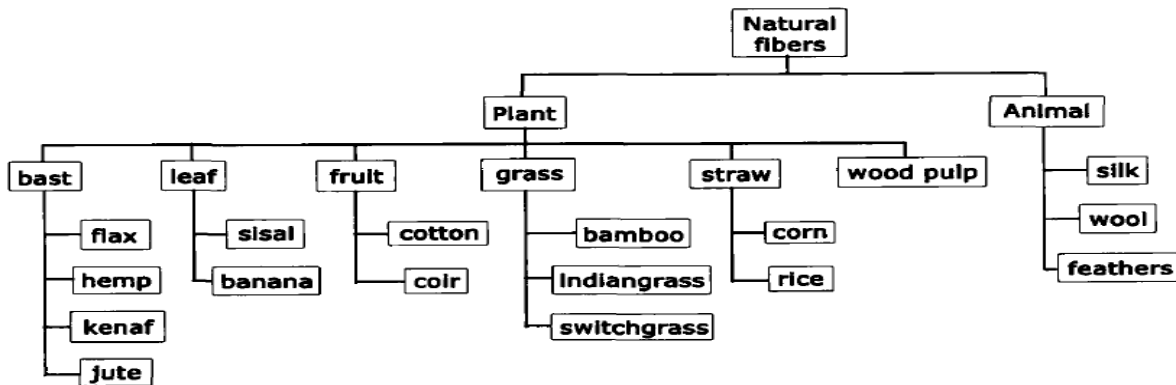


Fig 1. Classification of natural fibres [1]

Hemp: Hemp is a member of bast fibres comes under Cannabis family. Hemp is mainly used in Europe and is grown in temperate regions.

Kenaf: Kenaf is a new crop in United States which has about three hundred species and is used as a reinforcement in composite products. Kenaf is also a member of bast fibres.

Flax: Flax also comes under bast fibres and is grown in temperate regions. It is one of the oldest fibres and is mainly used in composite area and in textile markets.

Jute: Jute has the highest production and is one of the cheapest natural fibres. Jute also comes under bast fibres. Jute fibre has a greater aspect ratio. Countries like India, China and Bangladesh provide the best condition for the growth of Jute.

Abaca: Abaca or banana fibre is produced in Equador and Phillippines. It is extracted from banana fibre. Abaca is resistant to sea water and thus used for marine applications.

Oil Palm: Oil palm is a waste or cheap product and thus can be converted into beneficial products of higher value. Countries like Malaysia and Indonesia provide the best condition for the growth of oil palm.

Sisal: Countries like East Africa and Brazil had started growing sisal. The worldwide demand for sisal fibre was decreased between 1998-2000 and 2010 by a yearly rate of 2.3% [1].

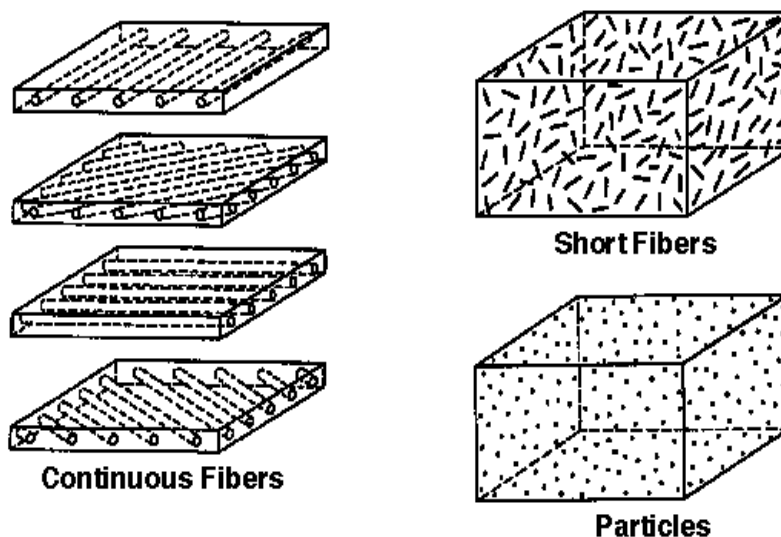


Fig.2. Fibre reinforcement form

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## III. CHEMICAL COMPOSITION

Natural fibres are composed of cellulose, hemicelluloses, pectin and lignin and some water cellulose compounds. Hemicellulose in the natural fibre cause biodegradation, thermal degradation and moisture absorption of the fibre as it has least resistance. Generally natural fibre contains 60-80% cellulose, 5-20% lignin and moisture upto 20%. This composition varies from fibre to fibre. [4][7]

Fiber	Cellulose %	Lignin %	Diameter ( $\mu\text{m}$ )	Hemicellulose %	Elongation %
Coir	37	42	100-450	0.15	47
Banana	64	5	50-250	6-19	3.7
Sisal	70	12	50-200	10-14	5.1
Pineapple	85	12	20-80	16-19	2.8
Jute	71	13	15.9-20.7	13-20	3.0

Table 1. Chemical Composition

### Moisture Content of Natural Fibres

Natural fibres contain a high percentage of cellulose which is hydrophilic in nature. Due to this hydrophilic nature of the fibres they tend to absorb moisture. This moisture content varies from 5-12 % and due to this the mechanical properties of the composites are affected. Due to the varying natural moisture of the atmosphere the natural fibres may shrink in dry environment or swell in wet environment because of this it shows poor mechanical properties [1].

### Chemical Treatment of Natural Fiber

Natural Fibres are chemically treated in order to modify its surface properties. This chemical treatment improves the surface adhesion. This chemical treatment is done with the help of Sodium hydroxide and process is known as Mercerization. The natural fiber is first scoured with detergent solution (2%) for about one hour and then it is washed with distilled water and afterwards dried in an air oven at 70°C. After this these fibres are treated with Sodium hydroxide solution. These fibres are kept dipped in NaOH solution in oven at 78°C for 3 hours. Afterwards these treated fibres are carefully washed with dilute acid in order to remove any alkali particles and then finally air dried. Due to this chemical treatment the specific interactions of fibres are improved to great extent as well as the wettability of the fibres is also enhanced [3].

### Advantages of Natural fibre Composites

- These composites have high stiffness.
- Have high specific strength.
- Produced at low cost as compared to synthetic fibres.
- Low density and low emission of toxic fumes during incineration and when subjected to heat.
- Low abrasive damage to the equipment.[5]

### Disadvantages of Natural Fibre Composites

- The major disadvantage of natural fibre composite is that it causes swelling due to high moisture absorption.
- These composites have limiting matrix options due to lower processing temperatures.
- In comparison to synthetic fibre composites these composites have lower durability.
- In comparison to synthetic fibre composites these composites have lower impact strength. [5]

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## Specific characteristics of Natural Fibre Polymer Composite

1. *Flame Retardent Properties:* Natural Fibre Polymer Composite are eco-friendly and are highly sustainable in comparison to synthetic fibre composites. Natural fibres are sensitive and can change any feature when the flame is inserted. Thus to fulfil the safety measures flame retardancy should be given importance when natural fibre is developed. When the composites are burned, two products are formed i.e. high lignin and high cellulose content. Char is formed when there is a high lignin content. On the other side high flammability occurs during high cellulose content. There are many fibres which are fire resistance such as flax fibre, to increase the fire resistance property of flax fibre ammonium polyphosphate and expandable graphite is added to composite polymer.. A number of barriers are used for creating resistance to fire such as use of additives and fire resistance coatings that increase the resistance of composites. The known fire retardants are magnesium hydroxide and aluminium hydroxide.

2. *Energy Absorption:* Composite materials which have high stiffness, strength and energy absorption are being used in motorsport and automotive sector as they have the mass reduction property. Energy absorption can be increased by increasing fraction of volume in low speeds like 2.5m/s. Similar performance has been seen at high speeds like 300m/s.

3. *Mechanical Properties of NFPCs:* Enhanced mechanical properties results in good structure and high strength. Factors that affects the performance of composites are:

- Physical properties of fibre
- Orientation of fibre
- Interfacial adhesion properties
- Strength of fibres

The mechanical efficiency of the natural fibre polymer composite depends upon the fibre matrix interface and stress transfer function. Some mechanical properties of NFPCs are moisture absorption, volume fraction, impurities and physical properties. For enhancing the mechanical properties chemical treatment of fibre is done to resist absorption of moisture and hydrophilic nature of fibres.

4. *Biodegradability:* Natural fibre have a very low environmental damage and short lifetime in comparison to synthetic fibres. The thermal stability of fibres can be improved by reducing the concentration level of hemicelluloses and lignin with the help of chemical treatment of fibres. Composites which have high strength provide high biodegradability. The degradation of natural fibres start at high and different temperature level as the constituents of fibre at this temperature start degrading.

5. *Tribiology properties of NFPCs:* All the materials are having some friction and wear properties that get damage or degrade with time. Thus the tribological properties should be considered necessary for improving mechanical part design. As their difference cause much failure in composites. The tribological properties can be altered positively or negatively by the reinforcement method. For example the kenaf fibre which are reinforced with epoxy composites showed 85% improvement in wear performance when used for bearing applications. Also the natural fibres such as nettle, grewia, optiva and sisal are used to make laminated composites by hot compression method and then the wear and friction properties are analysed. The results showed an approx reduction of 10-44% in coefficient of friction.

6. *Viscoelastic behaviour of NFPCs:* The viscoelastic behaviour of natural fibre polymer composites determines the interface characteristics and important insight into the structure morphology over a range of temperature. The maximum energy that is stored in the material in single cycle of oscillation is measure by storage modulus which gives information about the stiffness behaviour and load bearing capacity. The ratio of loss modulus to the storage modulus is called the mechanical damping coefficient.

7. *Thermal properties of NFPCs:* The OPFs when treated are observed to be more stable than the untreated ones and also they are seen more stable than some of the natural fibres like flex, hemp fibre. The thermal and surface properties of the natural fibres can be improved by enzymatic treatment. Chemical treatment of the fibres improves the fibre surface topography, tensile strength and thermal stability.

8. *Relaxation Behaviour of NFPCs:* All the natural fibres have an intrinsic relaxation behaviour which plays an important role in the stress relaxation behaviour of NFPCs. It has been seen that by doing surface treatments the fibre stress relaxation was decreased thus decreasing the physical interaction between fibre surface and latex particles. Also in some composites the stress relaxation rate seems to be reduce by increasing the fibre percentage.

9. *Water absorption characteristics:* The main weakness of the natural fibres is their moisture absorption property. Mechanical properties strongly depend on the interface adhesion of fibre and polymer matrix. These fibres contain

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cellulose and hemicelluloses in large amount and thus are hydrophilic in nature. Large intake of water cause decrease in strength and weakens the interface region between natural fibres and matrices which results in swelling, buckling, and warping. Chemical treatments such as acetylation, bleaching and alkali treatment are done so as to reduce moisture absorption and improve the adhesive properties of natural fibre [6].

## IV. LITERATURE SURVEY

*Ajitanshu Mishra et al* evaluated that natural fibre reinforced polymer composite are uses in a wide range for both in fundamental research and also for the engineering purpose. They can be easily recycled, and they are cheaper in cost. This paper deals with review of diff. type of natural fibres reinforced polymer composite along with its manufacturing processes and characterization especially coir and jute fibres as they are light weight , cheap and have good mechanical properties. They are a very good replacement for synthetic fibres [4].

*Anurag Kumar et al* reviewed in this paper that jute fibre reinforced polyester composite is made using pultrusion process. The developed composite consists of natural jute fibre as reinforcement and unsaturated polyester resin as matrix with hybrid filler containing bagasse fibre, carbon black and calcium carbonate (CaCO<sub>3</sub>).The effect of the weight of carbon black, bagasse fibre and calcium carbonate is seen on the tensile strength of the composite. Different composition of hybrid fillers are made by mixing three fillers and seen. The tensile strength at the optimum composition of filler with 15% weight of filler was 73.12MPa [8].

*Nirupama Prasad et al* reviewed in banana fibre is used to make eco-friendly composites. They were fabricated at different fibre loading but at 25% wt. banana fibre was seen optimum. To increase the compatibility between the banana fibre and LDPE matrix. The alkali and acrylic acid treatment was done in presence of compatibilizer i.e. maleic anhydride grafted LDPE. The tensile strength was increased of the treated fibres compared to untreated ones. It also show that further addition of acrylic acid lead to disintegration of fibres. The use of compatibilizer leads to less water absorption [9].

*Satish Pujari et al* reviewed that the thermal conductivity of banana and jute fiber epoxy composites at different volume fraction of fibre by heat flow meter method. The results showed that thermal conductivity decreases with the increase in fibre loading. Also conductivity of banana fibre was is less than jute fibre which showed that banana fibre is a good insulator. The conductivity of jute varied from 0.231 and banana fibre varied from 0.228 in temp ranging from -20°C to 300°C [10].

*M.Ramesh et al* reviewed the preparation of banana fibre reinforced epoxy composites and the mechanical properties of these composites are evaluated. The composite samples with different fibre volume fractions were prepared by using the hand lay-up process and apply pressure at room temperature. The samples were subjected to the mechanical testing such as tensile, flexural and impact loading. Scanning electron microscope (SEM) analysis is carried out to evaluate fibre matrix interfaces and analyze the structure of the fractured surfaces [11].

*K.N.Indira et al* reviews the storage modulus,loss modulus of banana fibre as a function of fiber content, fiber treatment, temperature and frequency. It has been seen that storage modulus increased with the increase in fibre content and was optimum at 40 % fibre loading. The loss modulus also increases with the increase of the fibre loading and was optimum at 10-20% [12].

*Haydar U Zaman et al* review paper deals with the preparation of banana fibre polypropylene composites by compression moulding and their mechanical properties are evaluated. The banana fibres were irradiated with UV rays at different intensities and then treated with MeOH solution. The mechanical properties were evaluated and compared with the untreated one. This review shows that an irradiated banana fibre based composite shows better result than untreated ones [13].

*Mark Hughes* reviewed the defects of the natural fibres and also the effect they cause on composites. Selected natural fibres are taken into consideration and their properties are studied. Also the effect of dislocations on the composite is also seen. It has been seen that bast fibres reinforced composites shows excellent properties. It has also been seen that



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the use of vegetable fibres reduce the occurrence of defects and also that the growing conditions of fibres influence the occurrence of defects. Separation of flax fibre into ultimate's cause the increase in tensile strength has been seen [14]. Noorunnisa Khanam *et al* has done the surface treatment of sisal fibre and then sisal fibre reinforced polyester is prepared. The effect of this fibre treatment on tensile, flexural and chemical properties were studied. The treatment was done in NaOH solution at diff. concentration. Untreated sisal fibre reinforced polyester composite was also prepared for comparison. The result showed that at 18% NaOH concentration the results were optimum and showed improved tensile and flexural strength. Also the treated sisal fibre composite showed better result compared to untreated one [15].

A.S.Singha *et al* had a review in which pine needles are used as reinforcement in polymer composites. Urea formaldehyde resin is synthesized and optimized. Pine needles are cost effective .Optimized resin is then reinforced with pine needles of different dimensions. It has been observed that the reinforced composites have increased tensile and compressive strength and also have good wear resistance. It has also been seen that particle reinforced fibres showed much better result than short and long fibres. Thus we have seen that pine needles reinforced composites are very cost effective and possess good mechanical properties [16].

## V. CONCLUSION

Natural fibre polymer composites are eco-friendly in nature as compared to synthetic fibre reinforced polymer composites. These fibres have high stiffness, less abrasive damage, renewable, non-toxic and possess good mechanical strength which makes them a very good option for using as a reinforcement in NFPC. The effect of chemical treatment on natural fibres improves their mechanical properties, reduces moisture absorption and also improves adhesion between fibre and polymer matrix. It has also shown a very good mechanical strength when loaded with fibre. The best results are obtained between 15% to 25% fibre loading.

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