

## Natural Fibers Reinforced Advanced Materials

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### Abstract

The increasing environmental concerns and depletion of petroleum resources has forced the researchers around the globe to find new green and advanced materials. In present review, a particular interest was focused on composites, advantages of natural fiber over glass fiber and the effective use of lignocellulosic natural fibers as reinforcement in composites.

**Keywords:** Natural fibers; Petroleum; Glass fiber; Lignocellulosic; Reinforcement

### Introduction

Increasing environmental concerns and depletion of petroleum resources calls for new green eco-friendly materials. Among various natural polymers, cellulosic natural fibers are envisioned as the most suitable ways to solve these problems especially environment related issues. The potential of cellulosic fibres as reinforcement in composite materials have been well recognized since many centuries ago.

The term 'composite' has been used in material science refers to a material made up of a matrix containing reinforcing agents. The beginning of composite materials may have been the bricks, fashioned by the ancient Egyptians from mud and straw. Nearly 70 years ago, a number of technical products and other commodity materials were derived from natural resources e.g., textile ropes, canvas and paper were made of local natural fibers such as flax and hemp. Emergence of polymers in the beginning of the nineteenth century inculcated the new era of research based on exploring the viability of natural fibers and their applications in more diversified fields. At the same time, interest in synthetic fibers due to its superior dimensional properties, gained attention and slowly replaced the natural fibers in major avenues. With the passage of time, the accumulation of the hazardous synthetic byproducts and waste, started polluting the environment and once again led the scientists towards natural fibers due to their distinct advantages. Thus, the renewed interest in the natural fibers resulted in a large number of modifications in order to bring it equivalent and even superior to synthetic fibers. After tremendous changes in the quality of natural fibers, they emerged as a substitute for the traditional building materials including lumber steel, portland cement and lime. Considering the high performance standard of composite materials in terms of durability, maintenance and cost effectiveness, applications of natural fiber reinforced composites as construction material, have done wonders and are environment friendly material for the future [1-8].

### Emergence of Natural Fiber Reinforced Composites

Many shortcomings due to high density and poor recycling properties were seen in glass fiber reinforced plastics. Moreover, glass fiber dust produced during processing triggers allergic skin irritation. The possible substitution of glass fiber by natural fiber in exterior application raised the question about mechanical properties of the material, flammability and effect of weathering. Natural fibers offer several advantages over glass fibers:

(i) Plant fibers are renewable and their availability is unlimited.

(ii) When natural fiber reinforced plastics are subjected to combustion or landfill at the end of their life cycle, the released amount of carbon dioxide is less with respect to that assimilated during its life cycle.

(iii) Natural fibers are less abrasive and can be easily processed as compared to glass fiber.

(iv) Natural fiber reinforced plastic, consisting of biodegradable polymer matrix are environment friendly and can be composted easily.

### Utilizing the Natural Fiber as Reinforcement in Composites

Natural fibers are being used by the mankind for centuries together for various applications in order to meet the basic requirement of shelter, food and clothes. In most of the countries, people have explored the possibilities of using natural fibers such as cotton stalk, rice-husk, rice-straw, baggase, cereals-straw and kenaf for a wide range of domestic and industrial applications. Most of these fibers have primarily been used for of particle boards. Work on reinforcement of composite with barley stalk has been reported by Bouhicha et al. [1]. Importance of indigenous natural fibers in preparation of composites over synthetic fibers has been reported by Paramasivam and Kalam [2]. Lee et al. [3] developed the novel short silk reinforced polybutylene succinate bio-composites by compression molding method and observed that there was improvement in tensile and flexural properties. Joseph et al. [4] fabricated composites reinforced with banana fibers by varying fiber length and fiber loading. The analysis of textile, flexural and impact properties of these composites revealed that the optimum length and type of banana fiber was different in phenol-formaldehyde resole material. Interlocking between the banana fiber and phenol formaldehyde resins was much higher than that between glass and phenol formaldehyde resin.

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## Development and Challenges faced by Natural Fiber Reinforced Composites

Askargorta et al. [5] studied the wetting behavior of flax fiber and possible replacement of polypropylene by flax fiber as reinforcement for the preparation of composites. Escamilla et al. [6] observed that grafting of polymethyl methacrylate or polybutylacrylate on the cellulosic fiber resulted in lower mechanical strength than those of ungrafted cellulosic fibers on their use in composites as reinforcing agent. Donnell et al. [7] made use of vacuum infusion process for the preparation of composite panel out of plant oil based resin and natural fibers. They used recycled paper as cheap source of cellulose fiber and used mats of flax, cellulose pulp and hemp as reinforcement. These low cost natural composites were found to possess mechanical strength and other properties suitable for the application in house construction materials, furniture and automotive parts.

Cement paste and mortar reinforced with different lengths of jute fiber were studied for direct tension, flexural, axial compression and impact strength. Jute fibers could be used to develop low cost construction materials particularly for roofing, wall panels and other building materials [8]. Reinforcement of cement mortar with about 80% sisal pulp by mass provided 50-60 fold increase in fracture toughness over the neat matrix [9].

Use of lignocellulosic fibers as reinforcement in thermoplastic and thermosetting resin for developing the low cost and light weight composites was reviewed by Mishra et al. [10]. Physico-chemico-mechanical properties of plant cell wall as fibrous lignocellulosic composites were studied in relation to shrinkage and water swelling behavior [11]. Khanbashi et al. [12] studied the potential of using date palm fibers as reinforcement in polymeric materials. An empirical formula to predict the ultimate strength of fiber reinforced concrete was given by Shanmugam and Swaddiwudhipong [13]. Feasibility of low cost yet strong engineering materials from natural sources was explored by Castino et al. [14] for preparing the laminates of urea formaldehyde reinforced with natural fibers. Satyanarayana et al. [15] found new uses of natural fibers as reinforcement for polyester based composites. Performance of these composites was evaluated after exposure to indoor and outdoor weathering by both destructive and non-destructive testing methods.

Dweib et al. [16] developed natural composites roof for housing facility, structural panels and unit beams out of soybean oil based resin using vacuum assisted resin transfer molding technology. These composites as building construction materials introduced many advantages such as high strength and stiffness with weight, susceptibility to severe weather conditions, desired ductility, fatigue resistance and design flexibility. McMullen [17] reported the development of composites consisting of gelatin and starch reinforced with cellulose fibers for use in aircraft structures.

Composites consisting of short wheat structure fibers with better resin penetration and fiber wetting have been found to depict high strength. The flexural strength increased by 40% on butyrate lignin adhesion [18]. In case of flax fiber loaded with approximately 8 to 10% by mass, flexural strength increased that was comparable to *Pinus radiata* fiber reinforced cement mortars. However, the fracture toughness values were approximately half to that of the *P. radiata* composites. Hence, flax fibers were not effective for asbestos fiber replacement as are *P. radiata* fiber [19]. Rousion et al. [20] manufactured hemp/kenaf fiber-unsaturated polyester composites using resin transfer molding process. Their tensile and flexural strength

were analyzed. Reinforcement of cement mortar with bamboo mesh imparted considerable ductility, toughness as well as its tensile, flexural and impact strength [21]. Maffezzoli et al. [22] formulated cardanol matrix based bio-composites reinforced with natural fiber. Bledzki et al. [23] improved the properties of epoxy resins and polypropylene composites through reinforcement with mercerized flax and hemp fibers. Mechanical properties of the fiber were monitored by focusing on mercerization parameters. Triglyceride oils derived from plants were used in the preparation of polymers with a wide range of physical properties and their reinforcement with 20% hemp fibers displayed a tensile strength of 35 MPa. In case of reinforcement with flax fiber, tensile and flexural strengths were found to be in the range between 20-30 and 45-65 MPa, respectively. However, hybrid composites like reinforcement with both glass and natural fibers showed properties in between the two [24].

Aggarwal [25] developed bagasse-cement composites and physico-mechanical testing showed that these composites met most of the requirements of various standards on cement-bonded particle-boards and had high performance even in moist conditions. Coutts and Ni [26] reported bamboo fibers as a potential reinforcement for autoclaved cement building material. On fiber loading of 14% by mass, the composite gave flexural strength greater than 18 MPa and  $1.3 \text{ g cm}^{-1}$  densities but the fracture toughness was lesser than  $0.50 \text{ KJ m}^{-2}$ . Zhu et al. [27] reported the fabrication of banana fiber reinforced cement composites and fiber loading of 8-16% by mass resulted in increase in flexural strength by 20 MPa for use as commercially viable building materials.

One of the key problems for the successful applications of natural fiber reinforced composites is the compatibility issues and adhesion between the fibers and the polymer matrix. In order to solve this problem researchers have started modifying the surface properties of the fibers as well as using compatibilizer to increase the adhesion between the reinforcement and the matrix. As a result cellulosic fibers are now considered as potential reinforcements because of their easy renewability, biodegradability, availability, high toughness, low cost, low specific gravity, acceptable specific strength and enhanced energy recover y etc. The applications of cellulosic fibres are however primarily driven by price and a compulsory demand of ecological awareness. Varieties of types of cellulosic fibres are commercially available, such as *Hibiscus sabdariffa*, *Grewia optiva*, sisal, jute, flax and pine needles etc.

Among these fibers *Grewia optiva* and *Hibiscus sabdariffa* are recently exposed fibers and are presently being assessed as potential reinforcement in polymer composites. Because of its industrial utility *Hibiscus sabdariffa* is now being cultivated almost throughout the world. It takes about six months to mature. The mature plant serves as a source of bast fibers. Scanty information is available in the existing literature on the effective utilization of this fiber as reinforcement material. Chauhan and Kaith have made various attempts to utilize the fiber and explore its viability as backbone for graft copolymerization and as reinforcement to phenol formaldehyde matrix based composites [28-35].

## Conclusion

Natural resources are the gift of the God to the mankind. But, with time these renewable resources and natural fiber will soon deplete. So, there is a great need to sustain and procure them for the future. They should be used economically and wisely. We should seek more fruitful means to explore the maximum potential and utilize the natural fiber for the development of science and technology.

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## References

1. Bouhicha M, Aouissi F, Kenai S (2005) Performance of Composite soil reinforced with barley straw. *Cement and Concrete Composites* 27: 617-621.
2. Paramasivam T, Abdul Kalam APJ (1974) On the study of Indigenous Natural Fiber Composites. *Fiber Science and Technology* 7: 85-88.
3. Lee SM, Cho D, Park WH, Lee SG, Han SOK, et al. (2005) Mechanical properties of Phenolic Composites. *Compos Sci Technol* 65: 647-654.
4. Joseph S, Sreekala MS, Oommen Z, Koshy P, Thomas S (2002) A comparison of the mechanical properties of phenol formaldehyde composites reinforced with banana fibres and glass fibres. *Compos Sci Technol* 62: 1857-1868.
5. Aranberri-Askargorta I, Lampke T, Bismark A (2003) Wetting behavior of flax fibers as reinforcement for polypropylene. *Journal of Colloid and Interface Science* 263: 580-585.
6. Canche-Escamilla G, Cauich-Cupul JI, Mendizabal E, Puig JE, Vazquez-Torres H, et al. (1999) Mechanical properties of acrylate-grafted henequen cellulose fibers and their application in composites. *Composites Part A: Applied Science and Manufacturing* 30: 349-353.
7. Donnell AO, Dweib MA, Wool RP (2004) Natural Fiber Composites with plant oil based resin. *Compos Sci Technol* 64: 1135-1140.
8. Mansur MA, Aziz MA (1982) A study of jute fibre reinforced cement composite. *International Journal of Cement and Concrete Composites and Lightweight Concrete* 4: 75-82.
9. Monties B (1991) Plant cell walls as fibrous lignocellulosic composites: relations with lignin structure and function. *Animal Feed Science Technology* 32: 159-175.
10. Mishra S, Mohanty AK, Drzal LT, Misra M, Hinrichsen G (2004) A review on Pineapple leaf fibers, Sisal fibers and their biocomposites. *Macromolecular Materials Engineering* 289: 955-974.
11. Coutts RSP, Warden PG (1992) Sisal pulp reinforced cement mortar. *Cement Concrete Composites* 14: 17-21.
12. Al-Khanbasi A, Al-Kaabi K, Hammami A (2005) Date palm fibers as polymeric matrix reinforcement: Fiber Characterization. *Polymer Composites* 26: 486-497.
13. Shanmugam NE, Swaddiwudhipong S (1988) Strength of Fiber Reinforced Concrete deep beams containing openings. *International Journal of Cement Composites and Light weight Concrete* 10: 53-80.
14. Castano VM, Martinez L, Sanchez H, Arita L (1992) Preparation and characterization of Natural fiber-polymer resin composite. *Materials Letters* 15: 108-112.
15. Satyanarayana KG, Sukumaran K, Kulkarni AG, Pillai SG, Rohatgi PK (1986) Fabrication and Properties of natural fiber-reinforced polyester composites. *Composites* 17: 329-333.
16. Dweib MA, Hu B, Donnell AO, Shenton HW, Wool RP (2004) All Natural Composite sandwich beams for structural applications. *Compos Struct* 63: 147-157.
17. Mc Mullen P (1984) Fiber reinforced composites for aircraft primary structure: a short history 1936-1984. *Composites* 15: 222-230.
18. Thielemans T, Wool RP (2004) Bio-based carbon fibers and high performance thermosetting. *Composites Part A: Applied Science and Manufacturing* 35: 327-338.
19. Coutts RSP (1983) Flax fibers as reinforcement in cement mortars. *International Journal of Cement Composites and Lightweight Concrete* 5: 257-262.
20. Rouison D, Sain M, Counturier M (2004) *Compos Science Technology* 64: 629-634.
21. Mansur MA, Aziz MA (1983) Study of bamboo-mesh reinforced cement composite. *International Journal of Cement Composites and Lightweight Concrete* 5: 165-171.
22. Maffezzoli A, Calio A, Zurlo S, Mele G, Tarzia A, Stifani C (2004) Cardanol based Matrix bio-composite reinforced with natural fibers. *Compos Sci Technol* 64: 839-845.
23. Bledzki AK, Fink HP, Specht K (2004) Unidirectional Hemp and Flax EP-and PP-Composites: Influence of Defined fiber treatment. *J Appl Polym Sci* 93: 2150-2156.
24. Khot SN, Lascalea JJ, Can E, Morye SS, Williams GI, et al. (2001) Development and application of triglyceride based polymers. *J Appl Polym Sci* 82: 703-723.
25. Aggarwal LK (1995) Bagasse- reinforced cement composite. *Cement Concrete Composites* 17: 107-112.
26. Coutts RSP, Ni Y (1995) Autoclaved bamboo pulp fibre reinforced cement. *Cement Concrete Composites* 17: 99-106.
27. Zhu WH, Tobias BC, Coutts RSP, Langfors G (1994) Air-cured banana-Fiber reinforced cement composites. *Cement Concrete Composites* 16: 3-8.
28. Kaith BS, Chauhan A (2008) Synthesis, Characterization and Mechanical Evaluation of Phenol-formaldehyde composites. *E-Journal of Chemistry* 5: S1015-S1020.
29. Kaith BS, Chauhan A, Singha AS, Pathania D (2009) Induction of the morphological changes in Hibiscus sabdariffa fiber on graft copolymerization with Binary vinyl monomer mixtures. *Inter Jour Polym Anal Characterization* 14: 246-258.
30. Chauhan A, Kaith BS, Singha AS, Pathania D (2010) Induction of the morphological changes in Hibiscus sabdariffa on graft copolymerization with acrylonitrile and co-vinyl monomer in binary mixtures. *Malaysian Polymer Journal* 5: 140-150.
31. Chauhan A, Kaith B (2011) Evaluation of Morphological Transition in Advanced Materials. *Der Chemica Sinica* 2: 20-29.
32. Chauhan A, Kaith B (2011) Evaluation of Dynamic Materials procured from waste Biomass. *ISRN Material Science* 7.
33. Chauhan A, Kaith B (2011) Recycling the Cellulosic Biomass to Competent Material. *J Textile Science Engineering* 1: 1-5.
34. Chauhan A, Kaith B (2012) Physical, chemical, thermal, and mechanical assessments of Roselle-reinforced composites. *Journal of Polymer Engineering* 32: 127-133.
35. Chauhan A, Kaith B (2013) Evaluation of Sereni fiber reinforced composite. *J Eng Fiber Fabr* 8: 36-43.

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