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Natural Fiber Reinforced Composite: A Concise Review Article

Ashish Chauhan*, **Priyanka Chauhan and Balbir Kaith**

Department of Chemistry, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar 144 011 (Pb) India

Abstract

Fiber reinforced composites were in use since ancient times. Due to the disadvantage of the synthetic and fiber glass as reinforcement, the use of fiber reinforced composite gained the attention of the young scientists. The review article explores the use of variable fiber as reinforcement in composites. With the advancement of science and technology the new means of characterization and evaluation of physico-chemico-thermo-mechanical properties of the composite have been used that have explored the new horizon of utilizing them for various applications.

The term 'composite' in material science refers to a material made up of a matrix containing reinforcing agents. Reinforcement is the part of the composite that provides strength, stiffness, and the ability to carry a load. Wood is a natural composite of cellulose fibers in a matrix of lignin. In manufacturing, fibers are the most commonly used reinforcement that yields Fiber Reinforced Composite (FRC). The reinforcement is embedded into the matrix. Common matrixes include mud (wattle and daub), cement (concrete), polymers (fiber reinforced plastics), metals and ceramics. The most common polymer-based composite materials include fiberglass, carbon fiber and kevlar. Fiberglass is probably one of the most familiar reinforcing composite materials that were introduced in 1940, consisting of glass fiber reinforcement of unsaturated polyester matrix [1-3]. This glass fiber had numerous drawbacks that led to search for alternate substitute as reinforcement. Fiber as reinforcement to the composite had outstanding physio-chemico-thermo-mechanical performance, durability and eco-friendly nature that highlighted and promoted its scope.

The beginning of composite materials may have been the bricks fashioned by the ancient Egyptians from mud and straw. The ancient brick-making process can still be seen on Egyptian tomb paintings in the Metropolitan Museum of Art. Commercialization of the composites could be traced to early century when the cellulose fibers were used to reinforce phenolics, urea and melamine resins. Composites in the world of today have wide range of applications, wherever high strength-to-weight ratio remains and important consideration for use. Its principal use is found in automotive, marine and construction industries. In majority of cases, requiring high performance in the automotive and aerospace industries, the discontinuous phase or filler is in the form of a fiber. In most cases, composite matrices are the thermosets having carbon and ceramics for high temperature applications. Thermosets (epoxy, polysulfones) and thermoplastics (polyetherether ketone, polyimide) due to high strength and performance are pioneer for research and industrial applications. Nano-composites in the latest advances have high aspect ratio and improved electrical, mechanical and thermal properties that could be fabricated for various purposes [4-6].

The use of natural fiber as reinforcement in composite was a challenging task. Ferreria et al. [7] improved the fatigue strength by using hybrid fiber composites with a polypropylene hemp layer adjacent to the bond interface which was expected to produce more uniform stress in transient regions. Richardson and Zhang [8] applied flow visualization experiments using resin transfer molding for developing a better understanding of the mold filling process for hemp mat reinforced phenolic composites. *Eucalyptus urograndis* pulp used as the reinforcement for thermoplastic starch showed an increase of 100% in tensile strength and more than 50% in modulus with respect to non-reinforced thermoplastic starch [9]. Fiber reinforced composite materials offered a combination of strength and modulus that are either comparable to or better than many traditional metallic materials. Increase in the flax and jute fiber content in polyurethane based composites increased the shear modulus and impact strength. However, increasing the micro void content in the matrix decreased its strength [10]. Jayaraman and Bhattacharya [11] reported the mechanical performance of wood fiber waste based plastic composites and observed that tensile strength does not generally change with fiber content. Zulkifli et al. [12] prepared Natural Rubber (NR)-Polypropylene (PP) composites by increasing the amount of NR in PP by 5-20% increase in its composition, inter-laminar fracture properties as well as the resistance of material to delaminate crack propagation. With increase in NR amount of this inter-laminar fracture the toughness of composite material decreased. Thwe and Liao [13] studied the resistance of bamboo fiber-PP hybrid composites to hygrothermal aging and their fatigue behavior under cyclic tensile load. The use of maleic anhydride polypropylene as a coupling agent suppressed the moisture absorption and degradation in such composites. Herrera-Franco and Valadez-Gonzalez [14] reported that fiber matrix adhesion promoted the fiber surface modification on alkaline treatment and matrix pre-impregnation e.g. use of silane as coupling agent in case of henequen fiber-HDPE composite. The increase in mechanical strength was found to be raised between 3–43% for longitudinal tensile and flexural properties whereas in transverse direction, the increase was greater than 50% with respect to the properties of composites made of untreated fiber. Increase in stiffness was approximately 80% of the calculated values.

***Corresponding author:** Ashish Chauhan, Department of Chemistry, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar 144 011 (Pb), India, E-mail: aashishchauhan26@gmail.com

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Electrical properties of the wood polymer composites from agro-based materials such as banana, hemp and agave fiber using novolac resins have been reported by Naik and Mishra [15]. Mitra et al. [16] treated the unwoven jute fiber with precondensate like formaldehyde, melamine formaldehyde and polymerized cashew nut shell liquid-formaldehyde, prior to its use as reinforcing material for the preparation of composites. The treatment reduced the moisture absorbance of the jute. Kandola et al. [17] reported the fabrication of novel glass reinforced epoxy composites containing phosphate. Eichhorn and Young [18] studied the deformation in micro mechanics of natural cellulose fiber networks and composites. Kaith et al. [19,20], Singha AS et al. [21] prepared polymer matrix based composites using flax-g-copolymers, flax fiber and mercerized flax as reinforcing agent. It was observed that the reinforcement increased the endurance of the composite to higher loads as compared to pure polystyrene. Mercerized fiber was found to be more effective reinforcing agent for wear resistance, tensile strength and compressive strength as compared to the grafted fibers. However, reduction in moisture absorbance and increase in the chemical resistance on graft copolymerization was observed.

Chauhan A [22] utilized the *Hibiscus sabdariffa* (Roselle) stem as reinforcing agent in phenol formaldehyde matrix based composites. Roselle fiber was graft copolymerized with monomers like methyl acrylate, ethyl acrylate, butyl acrylate and acrylonitrile and used these graft copolymer as reinforcement in the composite. The grafted fiber and composites were characterized by SEM, XRD, TGA, DTA and evaluated for physico-chemico-thermal properties. It was observed that the modified grafted fiber incorporated into the composite enhanced the physico-chemico-thermo-mechanical competence. Since, the grafted monomer acted as a coupling agent. The mechanical evaluation was done on the basis of wear, tensile, compressive strength test, flexural strength, young's modulus and hardness. However, some variation was seen in few cases but in most of the cases the strength improved. The better mechanical behavior could be accounted due to compatible fiber-matrix interaction and orientation of the fiber. However, some deviation in the results could be justified by other governing factors for overall mechanical performance like nature and amount of matrix and fiber, orientation, distribution of the fiber with respect to the matrix axis, form of reinforcement used (woven or non-woven, grafted or ungrafted), strength of the interfacial bond between the fiber and matrix, length of the fiber (continuous or discontinuous), aspect ratio that on mere imbalance may lead to de bonding and cracking [22-32].

So, we have seen above that various researchers have utilized the low weight and high strength of fibers like hemp, flax, jute as reinforcement to form fiber reinforced composite. These reinforcements have improved the strength and properties of composites if used after the graft copolymerization of the fiber like Roselle. We are blessed with variable natural resources and fiber but very less has been explored and utilized as yet. Fiber reinforced composites are one of the means to utilize the natural resources. But, with time these renewable resources and fiber will soon deplete. So, there is a great need to sustain and procure them for the future use. 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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