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Editorial Corner

Trends and Developments in Natural Fiber Composites

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Throughout the human civilization the innovations in field of materials have been realized mainly due to the technological changes happened in terms of lifestyles, depleting man-made resources and ever increasing global ecological problems. This has made the researchers around the universe to look for more sustainable and versatile solutions for the above-mentioned issues. This has impacted in the alarming usage of green fibers in composite materials which has in turn benefited in keeping the tempo of tree growing which is essential for the endurance of mortality. Natural fibers are used either in fibrous or non-fibrous form and popularly known as natural fiber composites. They are obtained from different plant, animal and mineral resources. Plant or cellulosic fibers are the most preferred natural fibers because of their various eco-friendly properties and their capability to minimize world global energy crisis.

The natural fibers are accessible in various forms such as seed fibers (milkweed, kapok), grass fibers (bagasse, bamboo), leaf fibers (abaca, banana, curaua, sisal), bast fibers (jute, hemp, ramie, kenaf), fruit fibers (oil palm, coir), stalks (wheat, rice, maize) and wood fibers (hardwood and softwood) [1]–[25]. This plant based natural fibers are attractive mainly due to their biodegradable sustainable behaviour. They are reinforced efficiently with different polymers to consequence in natural fiber reinforced polymer composites. These composites possess several advantages like low cost, easy processing, recyclable and safe from human health point of few.

The natural fibers are extracted from the respective plants through several methods. Decortication and retting process are commonly used methods for separating bast stem and leaf fibers from their respective plants. In, decortication method, a decorticator is used for stripping the fiber bundles from the leaf or bast. A rotating wheel in decorticator consisting of a pair of blunt knives is going to crush the leaves and separate them for fibers. Next, the decorticated fibers will be washed with pure water and later dried under sun. Finally, the dried fibers are combed and made ready for further use. The other method utilized for separation of bast stem and leaf fibers are retting method. It is a process of treating a deseeded straw/ crop to various biological or chemical treatments and making fiber bundles more effortlessly detachable from woody piece of stem. Dew and water retting methods are two traditional retting methods employed. Dew retting method involves leaving the plant stem in the yield area to rot and should be continuously monitored for ensuring the bast fibers separation and quality. While the water retting method demands dipping of stem in the ponds or in the tanks or in slow moving rivers. This process may need a large

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amount of fresh water thus making it more expensive method but produces finer quality fibers compared with dew retting process [26]–[33].

Although the environmentally friendly advantages of natural fibers have made natural fibers to be used more frequently than synthetic fibers as reinforcement materials in polymeric matrix composite systems, these fibers have got some drawbacks which had limited their use in some polymer industries. The major detrimental feature of natural fibers are their poor moisture resistance and minimal strength characteristics which limits their utilization in moderate engineering and commercial applications when reinforced with polymer matrix composites. Momentous investigations have been made around the globe to allay the above-mentioned obstacles and researchers have come up with several physical and chemical fiber surface modification methods which will essentially improve mechanical interlocking behaviour between hydrophilic fibers and hydrophobic matrices thus resulting in enhanced performance in natural fiber composites which have made them suitable for global applications. The fiber treatment methods commonly used are pre-treatment method, dispersing agent method, compatibilizer method and coupling agent method. Matrix modification method involves adding some chemical coupling agents or compatibilizer to polymer matrices to enhance polymer reactivity and reinforcing fibers wetting property [34]–[60].

Although natural fibers have got some exemplary features to be implemented in certain automobile, household, and construction applications, they alone cannot exhibit enough mechanical properties to be exploited in several structural applications. The limited use of these fibers in structural applications is also attributed to their poor moisture absorption resistance as compared with manmade synthetic fiber composites. In this context, there is growing attention in the developing hybrid fiber composites constituting of synthetic and natural fibers which is enhancing the optimal use of natural resources and understanding the physico mechanical properties of composites prepared from natural and synthetic fibers. These hybrid composite materials are becoming more attractive structural materials nowadays due to their reduced production cost and improved mechanical properties. The term "hybrid" in hybrid composites refers to the material structure comprising of diverse mixture of matrices coupled with more than one reinforcing and filler materials. The main advantage of hybrid composite material systems is that, as it is composed of more than one fiber, if one fiber lags in some properties it will be compensated by the other fiber and helps in better cost balance as well as by proper material design considerations performance of the composites will be enhanced. The hybrid fiber reinforced polymer composites (FRPCs) are fabricated using different processes namely hand layup process, hydraulic press process, cold press process, compression molding process etc. [61]–[85].

The increasing environmental concerns around the world have made many engineering sectors to produce their products by utilizing natural fiber reinforced polymer-based hybrid composites. Also, their biodegradability, inexpensiveness and better strength properties make them to be effectively used in many industrial, structural, and commercial applications. Major car manufacturing companies in Germany including Mercedes, Audi, Ford, Daimler Chrysler, Volkswagen, Opel and BMW are making wide use of natural fiber reinforced hybrid composites for the production of some of their major automotive parts. Mercedes-Benz, one of the world's leading car manufacturers pioneered the use of jute-based polymer laminates for the development of door panels in their A-class vehicles. Also, some of the companies in Germany, are utilizing flax-hemp based needles in few of their high segmental cars. Other automobile giant Ford automobiles merchant Visteon automotive systems made an agreement with Kafus bio-composites to manufacture interior panels, fittings and linings using natural fiber hybrid composites. Audi Groups have introduced A2 Midrange cars where their door trim boards are being fabricated using flax-sisal mat reinforced polyurethane composites.

Some of the interior parts manufactured by some of the world's renowned car manufacturing companies include Roof cover, engine cover, engine insulation, interior insulation, bumper and sun visor (Mercedes-Benz); Boot liner, B-pillar and Door panels (Ford); Spare tyre lining, roadster, coupe, side and back door panels, seat backs, hat racks and boot lining (Audi); Door panels, headliner panel, boot lining, seat backs, noise insulation panels and molded foot well linings (BMW); Door panel, boot liner & lid finish panel and seat back (Volkswagen); Rear parcel shelf (Renault); Cargo floor tray, natural foams and seat padding (Volvo) to name a few. The sisal-based epoxy composites is used in the production of cylinders; banana fiber based polyester composites for manufacturing of projector covers, paper weights, voltage stabilizers and mirror casings; and coir fiber based polyester composites for fabrication of roofing, helmets and post boxes. Some vehicle interior parts like door panels, seat backrest, glove box, seat coverings, trunk floor and panels were made from sisal/flax reinforced thermosetting polymer, coconut fiber-natural rubber, wood-cotton fibers, leather-wool backing, cotton with Polyethylene/ Polypropylene Terephthalate based cotton fiber composites, while outer division of floor panel mat is prepared by using flax fiber reinforced polypropylene hybrid composite laminates. Door frames are made from hessian/jute cloth based phenolic composites using pultrusion method, while the door shutters were made from sandwiching jute-sisal composite laminates with wood plastic slabs. The sisal-glass fabric reinforced epoxy composites are used in fabricating high pressure compression molded sheets and coir fibers reinforced with cement materials of different lengths and thickness are used to fabricate roofing sheets.

Some of the other application fields of natural fiber reinforced hybrid composites are: Transportation sector (automobiles, railway coach interior parts, gears, boats), Construction and building industry (partition boards, floors, walls, false ceiling, partition panels, roof tiles, door and window frames), Electric devices (electrical appliances and pipes), Furniture (tables, chairs, bath units), Storage devices (post boxes, silos for grain storage, biogas containers), Every-day applications (suitcases, lampshades, helmets) [86]–[105]. The positive ecological behaviour and easy processing of natural fiber composites makes them appropriate to be used in all the above-mentioned applications which have and will serve for the betterment of each and every human being across the universe. Overall, the invention of natural fiber composites has certainly been a boon for the earth for keeping its ecological balance in check and has also greatly helped in solving the global environmental issues in poise.

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