Green Bio composites: A Sustainable Resource for the Future

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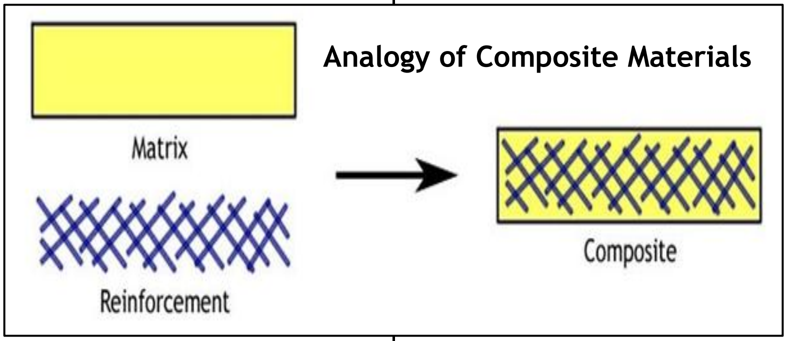
Sustainability is becoming an ever more compelling argument in the materials selection process. The current world environment scenario demands new and more eco-friendly solutions to global problems that cover the need for sustainable resources. A composite material is defined as a two-component system, where two dissimilar materials are integrated together to produce a new type of material with improved functionality. Two important components are typically termed as matrix phase and dispersed phase or reinforcement. A bio-composite is a composite material formed by a matrix (resin) and a reinforcement of natural fibres. Environmental concern and cost of synthetic fibres have led the foundation of using natural fibre as reinforcement in polymeric composites. The matrix phase is formed by polymers derived from renewable and non-renewable resources. Bio-composites are strong, lightweight and durable materials which are emerging as a viable alternative to glass fibre reinforced composites and finding applications in various industrial sectors.



Green Bio composites

Green composites are classified as a bio-composite that are generally constructed by the incorporation of a biodegradable polymeric matrix reinforced by eco-friendly and renewable fibres. They are called green bio-composites mainly because of their degradable and sustainable properties, which can be easily disposed without harming the environment. Because of their durability, unique characteristic feature, superior functionality and environmental compatibility, green bio-composites are mainly used to increase the life cycle of products with short life. The growing awareness of depletion in petrochemical resources, limited reserves, and concern for reduced carbon footprint are the reasons for designing green bio-composites.

The green bio composites have potential to attract the traditional petroleum-based composites which are toxic and non-biodegradable. The green bio composites eliminate the traditional materials such as steel and wood with biodegradable polymer composites. In a situation like increment in oil price, the use of green bio composites is helpful not only in making the environment better but also from an economical perspective as these are less in cost and are decomposable.

Two Main Components of Green Bio composites

Green bio composites are continuously being developed by embedding natural fibres with renewable resource–based biopolymers such as cellulosic plastics; polylactides; starch plastics; polyhydroxyalkanoates (bacterial polyesters); and soy-based plastics.

A. Reinforcing Natural Fibres

Natural fibres in simple definition are fibres that are not synthetic or manmade and are categorized based on their origin from animals, mineral, or plants sources. Some of the natural fibres are in readymade form such as vegetable, cellulose (cotton and linen), and mineral (asbestos) fibres. The

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fibres are produced and provided by nature from various parts of the plants, trees, and geographies.

The advantages of natural fibre over synthetic fibre in terms of its relatively renewable resources are its abundance, less damage to processing equipment, low weight, low cost, good relative mechanical properties such as tensile modulus and flexural modulus and improved surface finish of molded parts composite. Loose fibre, nonwoven mats, aligned yarns, and woven fabrics are possible forms of natural fibre for composites, with aligned variants offering the best mechanical properties. The techniques utilized to fabricate green bio composites are based largely on existing techniques for processing plastics and conventional composite materials. Depending on the types and form of natural fibre–reinforced green bio composites, the processing techniques would be chosen accordingly. For instance, compression molding, extrusion, hand lay-up, injection molding, resin transfer molding, and sheet molding compound can be utilized for short natural fibres, while compression molding, filament winding, hand lay-up, pultrusion, and resin transfer molding can be appalled for long fibres. The properties and performance of products made from natural fibre bio composites depend upon processing techniques, the properties of their individual components, as well as their compatibility and interfacial bonding between polymer and fibre.

The market size of natural fibre bio composites is projected to grow at CAGR of 11.68% between 2021 and 2025. This growth is attributed to the high demand for natural fibre bio composites in the construction and automotive industries and driven by regulatory requirements and superior product performance. Lightweight, high stiffness-to-weight ratio, consumer awareness regarding recyclable, and bio-degradable materials are the advantages of using natural fibre composites in the composites market.

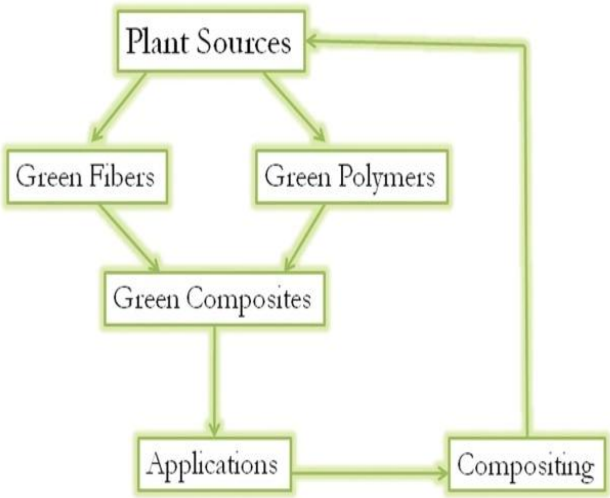
B. Biobased and Biodegradable Polymers:

Biopolymers are polymers obtained from natural resources and are consisting of monomeric units that are covalently bonded to form larger structures. Bio-polymers vary among their melt flow indices, impact properties, hardness, vapor transmission characteristics, coefficient of friction, and decomposition. Biopolymers can be thermoset, thermoplastic, and elastomer. One can find vast range of applications of biopolymers in different fields such as agricultural films, automotive, medical and pharmaceutical, food packaging, hygiene, and protective clothing. Because of the increasing environmental issues, the world has moved to the greener side, i.e., on zero or low emission side. The same case has been followed in the case of the composites development. Green bio composites is the main answer to this problem, as the name itself tells that the composite which is fabricated by reinforcing the natural fibres in the biopolymer matrix. These biopolymers degraded with respect to time so named as biodegradable type.

Biopolymers are cost effective and have great functionality as compare to the polymers derived from fossil fuel. The reason behind this is well known as the cost of the fuel or oil is very high as compared to the cost of available feedstocks such as starch; also the main advantage of using biopolymer is their biodegradability, which is of utmost important from the environmental point of view. Waste disposal problem has also been solved by the utilization of these biopolymers. The main aim for the development of biopolymers is their stability during storage and life cycle assessment. Biopolymers reinforced with natural fibres ultimately produced green bio composites which can replace the conventional or synthetic fibre reinforced composites.

Why Do We Need Green Bio composites?

The resins and fibres used in the green composites are biodegradable, when they are dumped, decomposed by the action of microorganisms. They are converted into the form of H_2O and CO_2. These H_2O and CO_2 are absorbed into the plant systems.



Life-cycle of Green Bio composites

Characterization of Green Bio composites

The greatest challenge in working with green bio composites is their large variation in properties and characteristics. The properties of green bio composites are influenced by a number of factors including the fibre type, environmental conditions (where the plant fibres are collected), processing methods, and any modification of the fibre. Careful selection of the reinforcing fibres and matrix biopolymers is the first step to obtain a composite with the desired properties in light of the intended application. The performance of natural fibre reinforced bio composites depends on several factors, including fibres chemical composition, cell dimensions, microfibrillar angle, defects, structure, physical properties, and mechanical properties, and also the interaction of a fibre with the polymer. To expand the use of natural fibres for composites and improved their performance, it is essential to know the fibre characteristics.

Physical Characterization

The advantage of natural fibre over synthetic fibre is increasing day by day because of its low cost, less weight, low manufacturing cost, abundance, renewable resources, relatively good physical and mechanical properties such as tensile strength, tensile modulus, bending strength and bio-degradable and environmentally friendly qualities. Natural fibres have been cultivated and used especially in rural developing countries for creating non-structural applications such as bag, broom, fishnet, and filters. The fibre's dimensions, defects, strength, variability, crystallinity, and structure are very important variables in measuring their physical properties. Knowledge of fibre length and width is necessary to compare natural fibres of different types. Major structural differences such as density, thickness of the cell wall, length, and diameter result in differences in physical properties.

Mechanical Characterization

Tensile, flexural and impact properties are the most widely studied mechanical properties of natural fibre-reinforced biopolymer composites. Impact strength in terms of mechanical performance is one of the undesirable weak points of such materials. In addition to these tensile, flexural and impact properties, the long-term performance (creep behavior), dynamic mechanical behavior, and compressive properties of green bio composites are also investigated. Several factors i.e., the kind of natural fibres, surface chemistry between fibre, type of fibres, moisture content and form of fibres and other composition and the quality of the interface should be considered to achieved desired mechanical properties of the green bio composites. These properties of the natural fibres depend on the types of natural fibres, their cultivation, growing period and extracting process, isolation and processing method. Mechanical properties of the natural fibres especially flax, abaca, kenaf, ramie, hemp, jute, sisal, bamboo, and bagasse are very good and strength and modulus are higher than synthetic fibre.

Potential Applications of Green Bio composites

Green bio composites use is of great importance in numerous applications including automotive, building and construction industries, sports, aerospace, and others, such as, decking, panels, window frame, and bicycle frame. Several automotive components and construction materials are already produced with natural fibres composites with various biopolymers where moderate strength, lower cost, and environmentally friendly properties are required. Some of the other areas in which the green bio composites are used includes false ceilings, partition purposes, doors, furniture and boxes for agriculture purposes. Other miscellaneous applications are rims, mobile panels, toys, aircraft, ships and so on.

Conclusion and Future Scope of Green Bio composites

- Green bio composites can be easily composted after their life, completing nature's carbon cycle. These can supplement and eventually replace petroleum-based composite materials in many applications, offering new agricultural, environmental, manufacturing, and consumer benefits.
- Eco-friendly green bio composites from plant-derived fibre (natural/bio fibre) and crop-derived plastics are novel materials of the twenty-first century and would be of great importance to the materials world, not only as a solution to growing environmental threat but also as a solution to the uncertainty of petroleum supply.
- Green bio composites have made an overwhelming impression on the world's economy as these are the materials of future and found applications in diverse markets including aerospace, automobile, packaging, shipping, biomedical, building etc.
- Many industries are seeking green replacement of the non-degradable and synthetic components used in their products to become a part of sustainable future. At present, this segment represents an important income for some economies, especially those where these resources are available, enhancing the creation of green economies, strengthening the world's efforts toward sustainability.

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