

# Recent Advances of Sustainable Composites in Manufacturing Sector

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Over the last two decades, there has been a resurgence of interest in the application of sustainable composites across diverse sectors, including aerospace, automotive, infrastructure, sports, and consumer goods [1]. This renewed interest can be attributed primarily to environmental and economic considerations. Natural fibers, such as kenaf, hemp, coconut coir, pineapple, abaca, flax, banana, sisal, bamboo, and jute, offer advantages over synthetic counterparts due to their recyclability, biodegradability, renewability, lightweight nature, lower density, reduced tool wear, and high specific mechanical properties [2]. The latest natural fibers under investigation include Phoenix sp, Ficus religiosa, Coccinia grandis, Albizia amara, Phoenix dactylifera L, Eleusine indica, Cardiospermum halicacabum, Acacia tortilis, Leucas aspera, red banana peduncle, Pithecellobium dulce, Ziziphus mauritiana, and others [3].

Environmental concerns, particularly related to recyclability and ecological safety, have urged research into clean and energy-efficient manufacturing processes for sustainable composites [4]. Notably, natural fibers have a neutral impact on CO<sub>2</sub> emissions, aligning with the objectives outlined in the Kyoto Protocol and sustainable development goals [5,6]. The demand for natural fibers is anticipated to grow significantly, with an estimated annual increase of up to 60% in the United States alone [7]. The natural fiber industry is predicted to experience an annual demand surge from 10% to 22% [7]. The quest for sustainable materials has led to a preference for biologically derived fibers and recyclable polymers, aiming to emulate the natural material use cycle. Thermoplastic-based sustainable composites have gained

prominence due to their biodegradability, reduced greenhouse emissions, diverse fiber options, rural job creation, low energy consumption, and cost-effectiveness [8,9]. In the present day, there is a growing interest in bio-based polymers [10]. Researchers worldwide are investigating the feasibility of expanding the use of bio-based polymers in composite manufacturing. Currently, the higher cost of biopolymers compared to non-biodegradable polymers is attributed to the inherent complexities in their processing [11].

The composite industry is increasingly acknowledging the necessity of integrating sustainability into its operations. Developments in new fiber materials and biopolymers, along with lifecycle analyses assessing the environmental impact of material production, as well as projects incorporating recyclable materials into diverse applications, are reshaping the industry's perspective on composite materials and their role in the future [12]. The establishment of a new research facility is required to facilitate sustainable manufacturing innovation, bringing together researchers specializing in polymers, chemicals, and sustainable composite materials. This type of initiative will help in uniting professionals and developers with expertise in polymer composites.

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