

### *Towards the Development of Value-Added Nanocomposites*

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The use of nanotechnology to improve the structural and functional characteristics of synthetic polymers has become a popular topic of study among material scientists and engineers (Jeevanandam et al. 2018; Khan et al. 2019). Despite the fact that the synthesis and use of nanotechnology for the manufacture of novel composite materials is well-known, there is a need to address the present issue of developing materials that are durable, sustainable, cost-effective, and environmentally benign (Mishra et al, 2018; Rahman et al. 2021a; Thiruvengadam et al. 2018). As a result, there is a lot of interest in continuing to look for low-cost reinforced composites made entirely of biodegradable and sustainable components (Girijappa et al. 2019; Rajak et al. 2019).

The world's need for wood rises in lockstep with the growth of the global economy with Asia-Pacific nations lead the global market. According to current estimates, worldwide wood commerce has surpassed more than a few billion cubic meters. This desire for high-quality timber has resulted in the non-renewable removal of hard wood in many developing countries, posing a major threat, particularly in Asia (Pirard et al., 2016). To minimize the impact on the environment, many nations have enacted legislation prohibiting commercial logging, resulting in a significant increase in the cost of natural wood goods, particularly in Borneo (Adhikari and Ozarska, 2018; Brack 2018; Gaveau et al. 2016; Ramage et al. 2017).

Natural fibers, other than extracted from the wood, i.e., bamboo, banana, kenaf, coconut, etc. have lately been investigated as potential replacements for several of these materials (Alsubari et al., 2021; Sreenivas et al., 2020). However, their mechanical characteristics, on the other hand, are frequently unsatisfactory (Alsubari et al., 2021). Bamboo fibers were the

only satisfied natural fiber that could be used as a commercial product other than Kenaf and Jute. Bamboo has long been favored because of its potential for producing materials that are recyclable, biodegradable, and extremely sustainable, particularly in light of recent discoveries that a mix of the matrix and natural fibers may produce composites with excellent strength-to-weight ratios (Fazita et al. 2016; Patti et al. 2021). Furthermore, each matrix component may be efficiently used for optimal characteristics as necessary in the production of a composite. It has been shown that bamboo may be used to create high-end, sustainable industrial goods that making it a customer choice (Rahman et al. 2021b). Bamboo fibers are also referred as natural glass fiber because of their high strength-to-weight ratio, making them an appealing alternative to steel in applications requiring tensile stress (Adamu et al. 2020; Li et al. 2000).

Due to its applications in industrial and scientific research in the manufacture of value-added materials with substantially enhanced physical and thermal characteristics, the synthesis of polymer-layered silicate (PLS) nanocomposite has recently gained a lot of attention (Ray and Okamoto, 2003). As compared with the traditional micro or macro composites, the synthesized PLS nanocomposites have demonstrated considerable improvement in terms of physical and mechanical characteristics (Camargo et al., 2009). Increased strength, decreased gas absorption and flammability, heat resistant, and quick biodegradability are among the qualities required for a variety of technical applications ranging from construction to home items (Folino et al 2020; Marichelvam et al., 2019). Due to the dispersion of the bamboo material's polymer matrix as a nanoscale inorganic filler, these characteristics have been re-engineered, resulting in an active interfacial region with better properties compared to those of the original bulk polymer (Rahman et al. 2021c; Szeluga et al. 2015). The inorganic filler particles could be reduced to nanoscale dimensions, which create a direct influence on their characteristics (Jeevanandam et al. 2018; Sasthiryar et al.2014). The nature and compositions of the inorganic filler, as well as the microstructure and interfacial interactions of the bamboo microstructure, all influence the ultimate characteristics of the produced nanocomposites (Camargo et al., 2009; Yu et al., 2014). Selecting an appropriate inorganic filler that will successfully interact with and modify the microstructure in a significant way is a critical stage in the development of a good nanocomposite material (Fu et al. 2019; Monika et al. 2011; Nassar et al. 2021).

Clay nanofillers have exceptional physical and mechanical characteristics when compared to traditional filler polymers like talc, glass fibers, carbon black, and calcium carbonate particles, and are commonly referred to as micro size fillers (Bhattacharya 2016). If the clay nanofibers are utilized, the bamboo fiber's processability, mechanical characteristics, and lightness may all be preserved, making them a popular choice in the polymer sector (Balla et al. 2019; Hassan et al. 2020). The well-layered structure of clay nanofiller is similar to

that of silicate minerals (Guo et al. 2018). Montmorillonite is the most frequent form of clay used as a nanofiller because of its availability and the fact that it includes alkali metal cations (Rahman et al. 2021c). It has a large surface area, a high swelling capacity, a strong cation exchange, and excellent absorption characteristics (Nadziakiewicz et al. 2019).

Research on composites and polymer blends, such as ethylene propylene have been conducted by Dinesh (2019). However, due of their polarity differences, most of these polymers become immiscible. Several attempts have been made to alter either the polymer or the composite to alleviate the compatibility problem (Oladele et al. 2020; Thompson et al. 2009). Some of the compatibilizers have resulted in poor and unacceptable mechanical characteristics. Weak contact between the compatibilizers and the composite was blamed for the poor mechanical characteristics (Durmaz and Aytac, 2019). Recently, the use of polymers with reactive groups, such as maleic anhydride, has gotten a lot of interest. The anhydride groups react with the hydroxyl groups in the composite to form a chemically bonded composite, resulting in composite dispersion, better interfacial adhesion, and improved mechanical characteristics (Kabir et al. 2012).

As a result of the advancements in nanotechnology, many chemicals and surface modification approaches may be used to improve the characteristics of nanocomposites. Acetylation, benzylation, corona/cold plasma maleisation, enzymatic, impregnation, isocyanate, peroxide, or salinization, are some of the methods that may be used. Thus, when comparing to the existing raw materials with the modified or value-added nanocomposites, the use of these techniques would improve the characteristics of the existing raw bamboo or the nanocomposites itself. In other words, if the method were properly utilized, not only the cost could be lowered, but the utilization of nanocomposites could also be expanded.

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