ACADEMIA | Letters

Bamboo and Its Bio-composites

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Bamboo (*Bambusa*) is divided into few subfamilies, with thousands of different species ranging from wood to bamboo and herb (Bakri et al. 2021). Bamboo products have been produced for thousands of years, thus it is rich in traditional features. As a result, the bamboo plant is considered to have beneficial characteristics such as propriety, serenity, and kindness. Also, each species of bamboo has unique traits and qualities (Emamverdian et al, 2020; Zakikhani et al. 2017). Bamboo is commonly utilized as a building material or a raw material for the manufacturing of paper sheets, erosion control and decoration. Bamboo is widely available across the world, with 64% of bamboo plantations coming from Southeast Asia, 33% from South America, and the remainder from Africa, and Oceania (Bonilla et al. 2010; Mohd et al. 2012). Bamboo is a natural product that has a wide range of uses and advantages.

Increased logging operations for several reasons have led to the forest's inability of absorbing carbon dioxide emissions. This results in an enormous amount of CO2 being released into the sky, trapping heat inside the atmosphere (greenhouse effect), and causing global warming. Environmental concerns have recently posed a danger to the environment's life cycle throughout the world, owing to countries use of non-biodegradable materials in industrial sectors around the world (Abdel-Shafy and Mansour, 2018). It has become a major issue since it is linked to the product lifecycle phase and is caused by the extraction or deposition of waste elements that are not properly disposed of.

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Citation: Bakri, M.K., Omoregie, A., Rahman, M.R. (2021). Bamboo and Its Bio-composites. *Academia Letters*, Article 2564. https://doi.org/10.20935/AL2564.

Bamboo has a lot of promise to be used as a solid wood replacement, particularly in design, building, and manufacturing. Bamboo's lightweight and high-strength characteristics have piqued the interest of researchers, particularly in the field of bio-composite bamboo, and it is recognized as one of the green technologies that are entirely accountable for eco-products on the environment (Adamu et al. 2020a; Adamu et al. 2020b). Many experts have recognized agricultural biomass solid wood manufactured from bamboo as the greatest source of natural fiber and cellulose fiber bio-composite, which are available at low cost and usher in a new era in the manufacturing world (Abedom et al. 2021). Bamboo's distinctiveness is recognized as a source of raw materials that can be processed and moulded into a variety of commodities like veneer, strips, lemongrass, and fiber, and it also adds a new dimension to the creation of bio-composite goods, particularly in terms of its value of diversity.

Advances in science and technology have led to the use of agricultural biomass as a raw material in manufacturing sectors, replacing solid wood and other non-biodegradable resources to increase industrial productivity and availability (Sadh et al. 2018). Bamboo's high flexibility and strength make it ideal for the building sector, and it's been used as a foundation structure. The development of bio-composite fiberboard is also utilized in wall construction, and it has the potential to contribute to the building of a more cost-effective home (Bharath and Basavarajappa, 2015). While the impact of the texture and tie on the exterior shell of bamboo has an exotic value while also giving it a distinct character in design, especially furniture.

Thermoplastic polypropylene matrices are the most often utilized bamboo fiber reinforcement nowadays (Rajak et al. 2019). Bamboo strips have a stronger cohesive strength than extracted bamboo fibers, in addition to numerous forms of bamboo shape. As a result, non-woven polypropylene is used to strengthen bamboo strips to create ultra-lightweight unconsolidated composites. Non-woven web can be used to reinforce materials in their natural state and take use of the reinforcing materials' inherent characteristics. Bamboo strips-polypropylene composites were discovered to have superior characteristics, including excellent flexural, acoustical, and sound dampening capabilities, making them a viable and ideal raw material to replace fibreglass presently utilized for car headliner substrates (Huda et al. 2012). Bio-composites may be used to make door inserts, trunk liners, pillar trims, parcel shelves, and load floors in the automobile industry, as well as field roofing, walling, and profiles in the construction industry. The impact of adding bamboo charcoal to a polyolefin thermoplastic polymer was examined in a few research papers. Bamboo charcoal's porous structure makes it an ideal medium for absorbing volatile compounds and reducing static electricity accumulation (Lou et al. 2007). Bamboo charcoal was chosen as a potential substance to improve the polyolefin's water absorption and electrical conductivity based on these two benefits.

Bamboo's potential and interest in thermoset composites is likely to follow the same pat-

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tern as thermoplastic composites. Bamboo fiber reinforced epoxy composites were tested to wear and friction to gain general acceptability for usage in a variety of applications (Nirmal et al. 2012). As the fibers were oriented anti-parallel to the sliding surface, it was claimed that wear volume was increased. Bamboo fibers are increasingly being used as a viable alternative filler reinforcement in elastomer composites (Ismail et al. 2002). Short fibers are utilized in rubber compounds because they have significant processing benefits, improve certain mechanical characteristics, and are cost-effective. The incorporation of short bamboo fibers into an elastomer polymer matrix, particularly natural rubber (polyisoprene), promises excellent mechanical properties in composites. Bonding agents (i.e., silane, phenol-formaldehyde, and hexamethylenetetramine) were discovered to have a key role in achieving excellent adhesion between fibers and rubber. Hysteresis, fatigue strength, modulus, elongation at failure, creep resistance over particle loaded rubber, hardness, cut, tear, and puncture resistance was all improved. The extraction of cellulose nano-whiskers from bamboo fiber waste was used as a reinforcing phase in a natural rubber matrix in the production of bio-green nanocomposites. The best starting material for making nano-whiskers is waste from the papermaking process, which is the bleached pulp fibers (Xie et al. 2018). The processing of cellulose nanocomposites was accomplished using a latex-based masterbatch preparation followed by mill compounding (Tan et al. 2012). It was discovered to be a feasible method for producing rubber-based nanocomposites that could be scaled up to a commercial scale.

Gloves, hoses, tires, v-belts, and complicated shaped mechanical items were all examples of elastomer composites in use (Fazli and Rodrigue, 2020). Carbon black made from bamboo has been utilized widely in tire manufacturing to increase initial modulus and durability. Bamboo carbon black, which was first employed as a reinforcing filler in tires in the twentieth century, resulted in a 10-fold improvement in tire service life (Aini et al. 2020). Aside from other forms of natural fibers, bamboo may also be burnt in a furnace at a specific temperature and heat to create carbon black. Since then, bamboo carbon black has served as the principal reinforcing ingredient in tyres and other rubber products. In most rubber compounds, carbon-black is used to make up around 30% of the total (Robertson and Hardman, 2021). As people pay more attention to environmental preservation, more natural fibers, particularly bamboo, are used as fillers to replace burned fossil fuels in a natural rubber polymer matrix, resulting in greener tires. Furthermore, the physical and mechanical qualities of the tires produced were improved to extremely desirable levels in terms of abrasion resistance and tread resistance. As a result, bamboo exploitation has undoubtedly improved the development of elastomer bio-composites.

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