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A Literature Review On Natural Hybrid Composite For Lightweight Smart Materials

Hridyanshu Yadav[a]*, Dr. Abhijeet Ganguly[b]

[a]M Tech Scholar, Department of Mechanical Enginnering, RSR Rungta College of Engineering and Technology, Bhilai (C.G.), INDIA.
[b]Head of Department, Department of Mechanical Enginnering, RSR Rungta College of Engineering and Technology, Bhilai (C.G.), INDIA.

ABSTRACT :

The study explores the development and application of natural hybrid composites in the context of lightweight smart materials. Emphasizing sustainability, this literature review consolidates recent advancements and research findings in the fabrication, characterization, and performance analysis of these composites. Natural fibers, due to their biodegradability, low cost, and favorable mechanical properties, have emerged as viable reinforcements in hybrid composites. The integration of natural fibers with synthetic or other natural fibers aims to enhance the material properties, achieving a balance between strength, durability, and weight. The review delves into the methodologies employed for composite preparation, including various fabrication techniques and treatment processes to optimize fiber-matrix interactions. Furthermore, the paper discusses the potential applications of these composites in smart material systems, where functionalities such as self-sensing, actuation, and environmental responsiveness are critical. By evaluating the current state of research, challenges, and future prospects, this review provides a comprehensive understanding of natural hybrid composites' role in advancing lightweight, eco-friendly, and multifunctional materials for diverse industrial applications.

Keywords:

1. Introduction :

A composite is a material made from two or more constituent materials with significantly different physical or chemical properties. When combined, these materials produce a composite material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure.

1.1 Constituents of Composites

The two main constituents of a composite material are:
Matrix: This is the continuous phase that surrounds and supports the reinforcement materials by maintaining their relative positions. The matrix material can be a polymer, metal, or ceramic.
Reinforcement: This is the dispersed phase that provides strength and rigidity to the composite. The reinforcement can be fibers, particles, or flakes, and it significantly enhances the mechanical properties of the matrix material.

2. Literature Review :

Rajak et al. [1] provide a comprehensive overview of composite materials, focusing on recent advancements in reinforcement materials. They discuss the significant progress made in enhancing the mechanical properties and performance of composites through innovative reinforcement techniques. The review highlights various types of reinforcement materials, including fibers, particulates, and nanomaterials, emphasizing their roles in improving the structural integrity and functionality of composites. The authors explore the potential applications of these advanced composites across various industries, showcasing their versatility and adaptability. This extensive review serves as a valuable resource for understanding the current state of composite materials and their future directions.

Naik et al. [2] review sustainable green composites, detailing their mechanical characterization, morphological studies, chemical treatments, and processing methods. The article underscores the importance of developing eco-friendly materials to reduce environmental impact. The authors examine various natural fibers and their potential as reinforcements in green composites, discussing the benefits of chemical treatments in enhancing fiber-matrix adhesion and composite performance. Additionally, they explore different processing methods to optimize the properties of green composites. This review provides a comprehensive understanding of the current state and future prospects of sustainable green composites in various applications.

Kamarudin et al. [3] review the potential of natural fiber-reinforced polymer composites (NFRPC) for sustainable industrial applications. They discuss the advantages of using natural fibers, such as biodegradability, low cost, and abundant availability, in reinforcing polymer matrices. The authors highlight the mechanical properties of NFRPCs, comparing them to traditional synthetic fiber composites. They also explore the environmental benefits and potential applications of NFRPCs in industries such as automotive, construction, and packaging. This review emphasizes the importance of developing sustainable materials to meet the growing demand for environmentally friendly products.

Senthilkumar et al. [4] investigate the mechanical characteristics of tri-layer eco-friendly polymer composites for aerospace applications. The study focuses on the development and testing of composites made from natural fibers and biodegradable polymers. The authors evaluate the mechanical properties, such as tensile strength, flexural strength, and impact resistance, of these composites. They also discuss the potential benefits of using eco-friendly materials in aerospace interior parts, including weight reduction, improved sustainability, and reduced environmental impact. This research highlights the potential of eco-friendly composites in high-performance applications, promoting the use of sustainable materials in the aerospace industry.

Chand and Fahim [5] provide an in-depth analysis of natural fibers and their composites, focusing on their tribological properties. The book chapter covers various natural fibers, their characteristics, and their potential as reinforcement materials in polymer composites. The authors discuss the mechanical and wear properties of natural fiber composites, exploring the factors that influence their performance. They also examine the environmental benefits of using natural fibers and the challenges associated with their use. This comprehensive overview serves as a valuable resource for understanding the tribological behavior of natural fiber composites and their applications.

Dempsey [6] explores the potential of banana fiber as a sustainable material for the fashion industry. The article discusses the process of extracting fibers from banana pseudo-stems, highlighting the environmental benefits of using agricultural waste to produce textiles. The author examines the properties of banana fibers, such as strength, durability, and biodegradability, comparing them to other natural fibers used in fashion. This study emphasizes the potential of banana fiber to reduce the environmental impact of the fashion industry by providing an eco-friendly alternative to conventional materials.

Reddy and Yang [7] discuss the extraction and properties of fibers obtained from banana pseudo-stems. The book chapter details the process of extracting banana fibers and their potential applications in various industries. The authors highlight the mechanical properties, such as tensile strength and flexibility, of banana fibers, comparing them to other natural fibers. They also explore the environmental benefits of using banana pseudo-stems as a renewable resource for fiber production. This research underscores the potential of banana fibers as a sustainable material for diverse applications, promoting the use of renewable resources in fiber production.

Subagyo and Chafidz [8] provide an in-depth exploration of the preparation, characteristics, and applications of banana pseudo-stem fiber. Their chapter in "Banana Nutrition - Function and Processing Kinetics" discusses the processes involved in extracting fibers from banana pseudo-stems and the unique properties that make these fibers suitable for various applications. The authors highlight the environmental benefits and potential uses in sectors such as textiles, composites, and paper products, emphasizing the sustainability and versatility of banana pseudo-stem fiber.

Muralikrishna et al. [9] investigate the mechanical properties of banana fiber composites in their study published in "Materials Today: Proceedings". They focus on the development and characterization of composites reinforced with banana fibers. The study examines various mechanical properties such as tensile strength, flexural strength, and impact resistance, demonstrating the potential of banana fiber composites for applications requiring high mechanical performance. The findings suggest that banana fiber composites could serve as a sustainable alternative to traditional synthetic composites.

Babu [10] discusses the role of eco-friendly green fiber-reinforced composites in mitigating global warming. The study highlights the advantages of using natural fibers in composite materials, including reduced carbon footprint, biodegradability, and sustainability. Babu emphasizes the need for developing green composites to replace conventional materials, thereby contributing to environmental conservation and combating climate change. This work underscores the potential of green composites in various applications, promoting a shift towards more sustainable materials.

Alam et al. [11] review the use of biocomposites in automotive components, highlighting their benefits and applications. Published in "Biocomposite and Synthetic Composites for Automotive Applications," the chapter discusses the mechanical properties, environmental benefits, and potential of biocomposites to replace traditional materials in the automotive industry. The authors explore various natural fibers, including banana fibers, and their effectiveness in enhancing the performance and sustainability of automotive parts. This review provides insights into the growing adoption of biocomposites in the automotive sector.

Kiron [12] provides a detailed overview of banana fiber properties, manufacturing processes, and applications in an article on Textile Learner. The study discusses the unique characteristics of banana fibers, such as their strength, flexibility, and biodegradability. Kiron outlines the steps involved in extracting and processing banana fibers and explores their applications in textiles, composites, and other industries. The article highlights the potential of banana fibers to serve as a sustainable alternative to synthetic fibers.

Venkateshwaran and Elayaperumal [13] present a comprehensive review of banana fiber reinforced polymer composites in the "Journal of Reinforced Plastics and Composites". They discuss the mechanical properties, fabrication methods, and applications of these composites. The review highlights the

benefits of using banana fibers as reinforcement, including their low cost, availability, and environmental advantages. The authors also examine the challenges associated with banana fiber composites and suggest potential solutions to enhance their performance and applicability.

Pandit [14] explores the characteristics and properties of banana fibers in a detailed article. The study focuses on the mechanical and physical properties of banana fibers, comparing them to other natural and synthetic fibers. Pandit discusses the extraction processes, potential applications, and benefits of using banana fibers in various industries. The article emphasizes the sustainability and versatility of banana fibers, making them a promising material for future applications.

Nguyen and Nguyen [15] investigate the mechanical properties and fire retardancy of banana fiber-reinforced epoxy composites in the "International Journal of Chemical Engineering". Their study examines the tensile strength, flexural strength, and impact resistance of the composites, as well as their fire-retardant properties. The findings demonstrate that banana fibers can significantly enhance the performance and safety of epoxy composites, making them suitable for various high-performance applications.

Rao et al. [16] provide a review of the properties of banana fiber reinforced polymer composites in "Materials Today: Proceedings". They discuss the mechanical, thermal, and tribological properties of these composites, highlighting the benefits and challenges of using banana fibers as reinforcement. The review covers various fabrication methods and applications, suggesting that banana fiber composites have significant potential for sustainable material development.

Fabbri and Messori [17] discuss the surface modification of polymers in their chapter in "Modification of Polymer Properties". The chapter explores various techniques for enhancing the surface properties of polymers, including chemical, physical, and mechanical methods. The authors highlight the importance of surface modification in improving the performance and functionality of polymer composites, including those reinforced with natural fibers such as banana fibers.

4. Conclusion :

This research focuses on the development and characterization of banana and coir fiber hybrid composites. The study will include the selection and preparation of natural fibers, the fabrication process of the composites, and a comprehensive analysis of their mechanical, physical, and microstructural properties. Additionally, the research will explore the smart material capabilities of these composites and their potential applications in various industries.

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