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Influence of Rice Husk Reinforced Material to Analyse Thermal and Fire Retardant Properties

B. S. Sridhar[1]*, H. S. Harish Gowda[1], G. Revanth[1], Siddaling[1], Josiah D. Cunha[1], A. R. Shashikala[2]

[1]Department of Industrial Engineering and Management, M S Ramaiah Institute of Technology, Bangalore – 560054, Karnataka, India; sridharbs@msrit.edu

[2]Department of Chemistry, Presidency University, Bangalore – 560064, Karnataka, India

Abstract

Natural fibers derived from agricultural waste have gained significant recognition in the polymer industries with more benefits, including their lightweight nature, cost-effectiveness, and eco-friendliness. Presently, there has been a growing emphasis on utilizing natural fibers as materials for fiber composites, driven by increasing environmental concerns. One such natural fiber of interest is Rice Husk (RH), which is the protective sheath that surrounds rice grains during their growth. Rice husk, being an agricultural waste, has emerged as a promising natural fiber for the development of bio-composites. The outer surface of the husk is covered with a silica layer, while the innermost epidermis contains a minimal amount of silica content. The utilization of rice husk residues in the production of bio-composites offers several advantages, such as reducing the dependence on synthetic polymers, including resin polymers and certain additives. This approach contributes to a more sustainable and environmentally conscious manufacturing process. This research concentrated on the influence of rice husk material on the structural, thermal, flammable, and mechanical properties. The thermal properties were characterized using Thermogravimetric Analysis (TGA). An automobile interior dashboard design is synthesised with a material keeping cost and price as the prime factor along with its strength, the structure is strengthened against an external force applied.

Keywords: *Dashboard Design, Epoxy Resin, Hardener, Rice Husk*

1.0 Introduction

In response to concerns regarding global warming and the depletion of petroleum reserves, researchers have increasingly focused on utilizing natural fibers in various applications. Sustainable alternatives such as bagasse, coir, sisal, and jute have gained attention, leading to the development of natural fiber-based composites with several advantages.

Natural fiber reinforcement in composites gained more importance due to its cost-effectiveness, easy availability, and desirable properties. These fibers possess characteristics such as low density, specific properties, ease of separation, energy recovery, and recyclability, making them attractive for composite materials. The mechanical properties of natural fiber composites are influenced by factors such as fiber diameter, content, density, size, geometry etc.

The environmental suitability and economic usage of natural fibers and their composites make them appealing for engineering applications. These materials are renewable, biodegradable, and offer a sustainable alternative to non-biodegradable synthetic materials. Natural fiber-reinforced epoxy composites enhance mechanical properties along with industrial applications.

**Author for correspondence*

Extinct research has been conducted on natural fiber composites, focusing on fibers like jute, hemp, sisal, coir, and others. Fibers with high cellulose content tend to offer superior performance, emphasizing the importance of selecting appropriate fibers for specific applications.

The increasing interest in natural fiber-reinforced polymer composites is driven by their industrial applications and the need for further research. These composites are lightweight, eco-friendly, biodegradable, and possess a high strength-to-weight ratio and specific modulus. They are also renewable, cost-effective, and recyclable, making them environmentally attractive.

Various plants, including flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, and wood, have historically been used in composites. The growing usage of natural fibers in composites demonstrates their recognized potential and benefits. The combination of natural fibers and polymers offers a versatile material system applicable to a wide range of engineering applications.

In conclusion, the exploration of natural fibers and their composites has gained momentum due to the demand for sustainable materials and the advantages they offer, including cost-effectiveness, availability, desirable properties, and eco-friendliness.

The composite materials are rapidly gaining popularity in industrial applications. These composites are renewable, recyclable, and biodegradable, making them attractive from an ecological perspective. Enormous material availability, low cost, and satisfying mechanical properties make them a viable alternative for manufacturing composites. The authors provided a comprehensive overview of the material attributes of natural available fiber composites and highlighted their various applications in industries such as transportation, construction, packaging, and consumer products[1].

The study focused on natural fibers, polymers, and their composites, as well as tribology developments. It discussed the adhesive wear mechanisms of different types of composites under various operating and test parameters[2]. The aim was to address the limitations of previous works and lay the foundation for future research on the tribology of polymeric composites.

The study also examined various surface treatments applied to natural fibers and their impact on the properties of NFPCs. The properties of NFPCs vary depending on the fiber type, source, and structure. The effects of chemical treatments on the mechanical and thermal properties of NFPCs in thermosetting and thermoplastic composites were investigated. The study highlighted drawbacks of NFPCs such as higher water absorption[3], inferior fire resistance, and lower mechanical properties, as well as the impact of chemical treatments on properties like water absorption, tribology, viscoelastic behavior, flame retardancy, and biodegradability. Applications of NFPCs in the automotive and construction industries were demonstrated[4]. The study concluded that chemical treatment improved the adhesion between natural fiber surfaces and polymer matrices, enhancing the physical, mechanical, and thermochemical properties of NFPCs[5].

The usage of natural resources which create fully or partially biodegradable composite materials as a step towards conserving the environment[6]. These alternative materials can be applied in various fields such as interior housing, automotive, marine, and domestic sectors. The authors emphasized the usage of composites reinforced with natural fibers in multiple engineering disciplines, highlighting their positive effects on mechanical behavior[7].

2.0 Problem Definition

The investigation aims to achieve two specific objectives:

Physical Property Assessment: The second objective is to evaluate the physical properties of the fiber-reinforced boards produced using the composite material. This includes assessing properties such as density (aiming for lightweight), strength (in terms of bending and impact resistance). By conducting tests and measurements, the investigation aims to quantify these properties and determine the behaviour of the composite material. This assessment will help ascertain whether the composite meets the desired specifications and whether it is suitable for its required applications, such as in the manufacturing of vehicle dashboards.

To achieve these objectives, a systematic experimental approach will be employed. Composite samples will

be prepared with varying compositions, encompassing different ratios of rice husk, glass fibers, epoxy resin, and a hardener.

3.0 Materials and Methodology

3.1 Rice Husk

Rice husk refers to the outer protective layer of rice grains, which is separated during the milling process to obtain polished rice. It is considered a byproduct of rice production and is often treated as waste. Composed primarily of cellulose, hemicellulose, lignin, and high levels of silica, rice husk offers valuable properties for various industrial and agricultural applications (Figure 1).



Figure 1. Rice husk.

3.2 Epoxy Resin

Epoxy resin is a synthetic polymer widely utilized in numerous industrial and commercial applications. It is a thermosetting resin, which when mixed with a hardener, it undergoes a chemical reaction which results in a rigid and durable material. Epoxy resin is compatible with different reinforcements, including glass fibers, carbon fibers, and aramid fibers. This versatility enables the production of high-performance composite materials that find applications in aerospace, automotive, and other industries (Figure 2).



Figure 2. Epoxy resin.

3.3 Hardener

A hardener is a chemical compound employed in combination with a resin to initiate the curing or hardening process. Forepoxy resin, the hardener is mixed with resin to enhance chemical reaction that transforms the liquid resin into a solid and resilient material. This reaction typically involves the formation of chemical bonds between the resin and hardener molecules, which results in a cross-linked polymer network responsible for the material's strength and durability.

3.4 Methodology

The methodology for this research project involves several key steps:

Material Preparation: A composite sandwich structure will be prepared using the selected natural fiber as the top layer and the rice husk as the sandwich layer. The fabrication process will involve techniques such as vacuum bagging to ensure proper consolidation of the layers and eliminate any voids or air pockets.

Experimentation and Data Collection: The fabricated composite sandwich structure will undergo a series of tests to evaluate its physical and mechanical properties. Specifically, tests for impact strength and flexural strength will be conducted using appropriate

testing methods. During these experiments, data of the composite material's performance will be collected and recorded.

Data Analysis: The data was analyzed and compared with existing materials commonly used in the automobile industry for interior applications. This results provide insights into the strength, durability, and other relevant properties of the composite material. The findings will be interpreted and discussed to assess the suitability of the developed material for practical applications.

4.0 Results and Discussion

4.1 Flexural Strength

The flexural strength test is conducted to analyse the strength of the composite material under bending conditions. The test involved applying a load to the specimen in a three-point or four-point bending configuration until failure occurred. The amount of force required to cause failure was measured.

In our experiments, the composite material exhibited a peak flexural strength of 3.06 MPa. This indicates the material can withstand bending forces without failure. Additionally, the modulus of elasticity was determined to be 588.76 MPa, indicating the stiffness of the material (Figure 3).

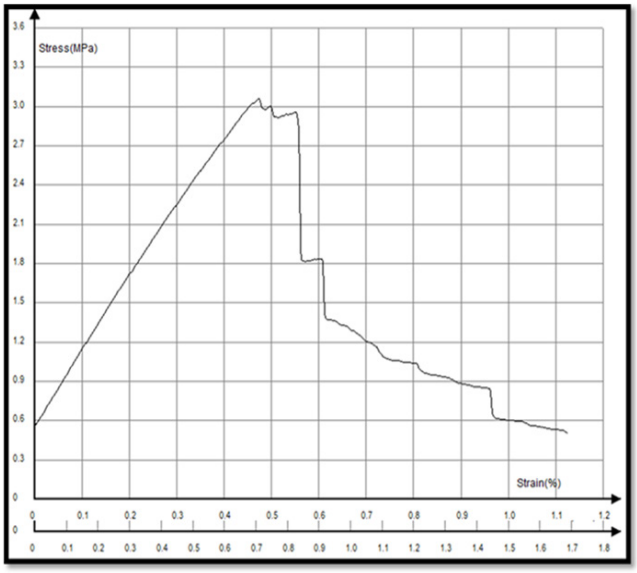


Figure 3. Flexural graph.

4.2 XRD Analysis

X-Ray Diffraction (XRD) analysis is to investigate the crystalline structure of the rice husk. The major component of rice husk, silica, typically exhibits diffraction peaks at around 2θ = 22.5° corresponding to the crystallographic planes (101) and (100).

The XRD graph obtained from the analysis showed characteristic diffraction peaks at the expected angles, confirming the presence of silica in the rice husk. This supports the composition of rice husk with cellulose, hemicellulose, lignin, and silica (Figure 4).

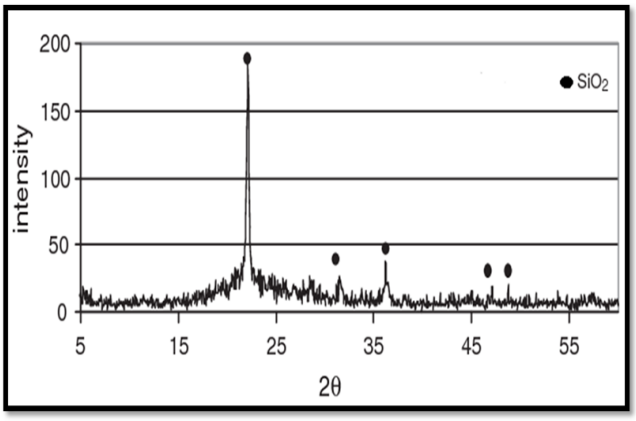


Figure 4. XRD graph.

4.3 TGA Analysis

Thermogravimetric Analysis (TGA) is analysed to assess the thermal stability and decomposition behavior of rice husk and its components. TGA involves subjecting

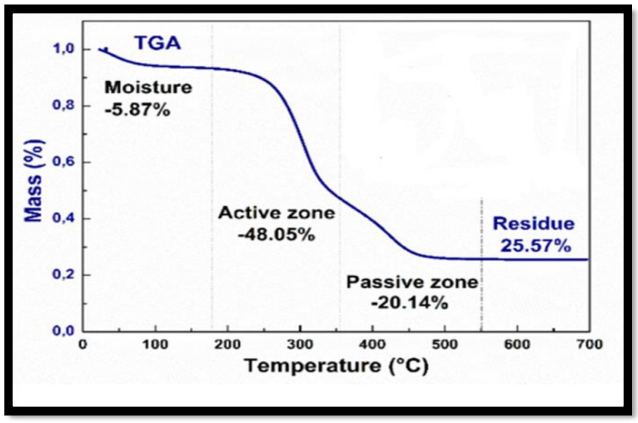


Figure 5. TGA graph.

the material to a controlled temperature increase while measuring the weight loss as a function of temperature.

In TGA analysis, initially weight loss occurred between 30-120 °C, corresponding to the loss of moisture from the material. The second stage, between 200-350 °C, decomposition of hemicellulose and cellulose. The third stage, between 350-500 °C, indicated the decomposition of lignin. Finally, at 500 °C and above, weight loss occurred due to the decomposition of remaining organic matter, leaving behind mostly ash and silica.

These TGA results discloses the thermal stability and decomposition behavior of rice husk and its components.

5.0 Conclusion

Overall, flexural strength test demonstrated the ability of the composite material to withstand bending forces, while XRD and TGA analyses provided insights into the composition and thermal properties of rice husk. These results contribute to our understanding of the performance and characteristics of the composite material and can guide its application in various fields.

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