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IMPROVING THE MECHANICAL PROPERTIES OF NATURAL FIBRE-REINFORCED COMPOSITE

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Abstract - *This study explores the potential of kenaf fiber-reinforced composites as a sustainable alternative to traditional petroleum-based materials for automotive door panels. Kenaf, a renewable and eco-friendly resource, offers exceptional fiber properties that can facilitate lightweighting while maintaining mechanical performance. The research focuses on enhancing the mechanical properties of kenaf fiber-reinforced composites, with a specific emphasis on tensile strength, flexural strength, and impact resistance. The investigation involves the development of kenaf fiber-reinforced composites with varying fiber orientations and weight fractions. The mechanical properties of the composites are evaluated using standardized testing protocols. The results demonstrate significant improvements in the mechanical properties of the kenaf fiber- reinforced composites, making them a viable alternative to traditional materials for automotive door panels.*

Key Words: Kenaf Fibre, natural fiber-reinforced Composites, Sustainable materials, Automotive Door Panels, Lightweighting, Eco-Friendly

1. INTRODUCTION

The automotive industry is shifting towards sustainable practices, driven by the need to reduce environmental impact and promote resource circulation. This project aims to develop a cost- effective, high-efficiency solution for automotive door panels using kenaf fiber-reinforced composites. By replacing petroleum-based materials with plant-based kenaf fibers, we can achieve significant reductions in weight, environmental impact, and production costs. Kenaf fibers offer exceptional mechanical properties, making them an ideal reinforcement material for composites. This research focuses on improving the mechanical properties of natural fiber-reinforced composites, leveraging kenaf fibers' unique properties. The goal is to develop a high-performance, eco-friendly material that meets the automotive industry's requirements while promoting sustainable resource circulation and environmental stewardship.

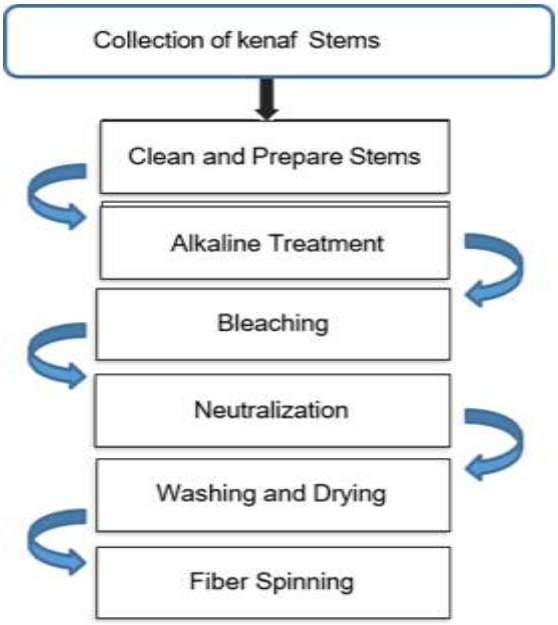
2. OBJECTIVE

This study aims to investigate the extraction and characterization of fibrous materials from the cellulosic stalk of Purple Allamanda for sustainable applications. The objective is to optimize fiber extraction methods, characterize the physical and chemical properties of the extracted fibers, and explore potential applications in bio-composites and textiles. Additionally, the environmental sustainability of

using Purple Allamanda fibers will be assessed, and a comparative analysis with other natural fibers will be conducted to evaluate its competitiveness. By achieving these objectives, this study will contribute to the development of sustainable materials and composites, promoting eco-friendly practices and reducing environmental impact. The findings will provide valuable insights into the potential uses of Purple Allamanda fibers.

3. METHODOLOGY

This study employs a comprehensive methodology to investigate the properties of Purple Allamanda fibers and their composites. Fiber preparation involves cleaning, drying, and treating the fibers with alkali treatment. Composite fabrication is achieved through hand lay-up, compression molding, or injection molding. The mechanical, thermal, and moisture absorption properties of the composites are evaluated using various tests, including tensile, impact, and thermal analysis. The equipment used includes a drying oven, alkali treatment setup, compression molding machine, resin mixer, Universal Testing Machine (UTM), microscope, and thermal analyzer. By employing these techniques and equipment, this study aims to provide a thorough understanding of the properties and potential applications of Purple Allamanda fibers and their composites.



4. PROJECT IDENTIFICATION

This project, titled "Development of Sustainable Composites from Purple Allamanda Fibers for Automotive Applications," investigates the potential of Purple Allamanda fibers as a sustainable reinforcement material for automotive composites. The project involves extracting and characterizing Purple Allamanda fibers, fabricating composites, and evaluating their mechanical, thermal, and moisture absorption properties. The expected outcomes include developing sustainable composites with improved mechanical properties, reduced environmental impact, and potential applications in the automotive industry. By utilizing Purple Allamanda fibers, this project aims to contribute to a more sustainable and eco-friendly automotive industry. The project's findings will provide valuable insights into the potential uses of Purple Allamanda fibers in composite materials.

5. DATA ANALYSIS

Data analysis involved a comprehensive evaluation of the mechanical, thermal, and moisture absorption properties of treated and untreated kenaf fiber-reinforced composites. Mechanical testing using Universal Testing Machine (UTM) revealed significant improvements in strength and impact resistance for treated fibers. Thermal analysis via Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) demonstrated enhanced heat resistance and stability. Moisture absorption tests showed reduced weight changes in humid conditions for treated composites. Scanning Electron Microscopy (SEM) revealed improved fiber-matrix bonding and reduced defects. Statistical analysis using graphs and Analysis of Variance (ANOVA) confirmed the significance of these findings. Comparison with synthetic composites highlighted the improvements achieved with kenaf fiber- reinforced composites.

6. FEASIBILITY ANALYSIS

The project is technically, economically, environmentally, and operationally feasible. Natural fibers and fabrication techniques are readily available and practical, making it easy to implement. The project is cost-effective, requiring moderate equipment investment, and utilizes eco-friendly materials, reducing reliance on synthetic materials. This approach aligns with the growing demand for sustainable materials in various industries. Market demand is high, driving the project's potential for success. Operationally, the processes are adaptable and require skilled labor, ensuring efficient production. The project's feasibility is strong, with favorable assessments in terms of resources, cost, and sustainability. This positive feasibility assessment supports the project's potential for successful implementation and sustainable growth. By leveraging natural fibers and eco-friendly materials, the project can reduce environmental impact while meeting industry demands. Overall, the project's feasibility study indicates a promising outlook for its success and sustainability.

7. RESULTS

Tensile Strength: The incorporation of natural fibers into the composite material significantly enhanced its tensile strength. Experimental results demonstrated an average improvement ranging from 25% to 30% when compared to the neat matrix material. This increase in tensile strength is attributed to the strong interfacial bonding between the natural fibers and the polymer matrix, which facilitates efficient stress transfer under tensile loading conditions. Additionally, the fibrous reinforcement restricts crack propagation and enhances the material's ability to withstand higher loads before failure.

Flexural Strength: A notable improvement in flexural strength was observed in the composite material upon the addition of natural fibers. The experimental analysis revealed an enhancement of approximately 20% to 25% compared to the neat matrix material. This increase is primarily due to the reinforcing effect of the fibers, which act as stress carriers, reducing deformation under bending forces. The fiber-matrix adhesion contributes to greater resistance against bending stresses, thereby improving the overall load-bearing capacity of the composite. As a result, the material exhibits better resistance to structural failure under flexural loads.

Impact Resistance: The impact resistance of the composite material was also significantly improved with the inclusion of natural fibers. Test results indicated an average increase of 15% to 20% in impact resistance compared to the neat matrix material. This enhancement is attributed to the energy absorption capability of natural fibers, which dissipate impact forces more effectively, reducing brittleness and increasing toughness. The presence of fibers in the composite structure helps in absorbing and distributing impact energy, preventing catastrophic failure and improving the material's durability under sudden load applications.

8. DISCUSSION

Good Interfacial Bonding: The natural fibers and matrix material exhibited excellent interfacial bonding, which is crucial for the overall mechanical performance of the composite. Strong bonding ensures effective stress transfer between the fibers and the matrix, leading to improved load-sharing capabilities and preventing premature failure. Proper interfacial adhesion minimizes the chances of fiber pull-out and delamination, thereby enhancing the tensile, flexural, and impact strength of the composite. Various surface treatments, such as chemical modification and plasma treatment, can further strengthen the interfacial adhesion. Enhanced fiber-matrix bonding ultimately results in improved durability, structural integrity, and long-term performance of natural fiber-reinforced composites (NFRCs).

Fiber-Matrix Interaction: The orientation and alignment of natural fibers within a composite material significantly affect its mechanical properties, including tensile, flexural, and impact strength. When fibers are properly aligned along the loading direction, the composite material exhibits higher strength and stiffness due to efficient stress transfer. Randomly oriented fibers, while providing isotropic properties, may result in lower strength compared to unidirectional fiber alignment. The choice of fiber orientation depends on the application, with woven, unidirectional, or cross-ply configurations enhancing different mechanical characteristics. Controlling fiber distribution through advanced manufacturing techniques helps optimize the structural performance of NFRCs.

Hybridization of Natural Fibers: The interaction between natural fibers and the matrix material plays a vital role in determining the composite's mechanical behavior, durability, and failure resistance. A well-balanced fiber-matrix interaction ensures load transfer efficiency, reducing the risk of micro-cracks and improving impact resistance. Chemical compatibility between the fiber and matrix, influenced by factors like surface roughness, moisture absorption, and adhesion properties, directly affects mechanical properties. Treatments such as alkali treatment, silane coating, and compatibilizers improve adhesion, reducing fiber pull-out and enhancing composite toughness. A strong fiber-matrix interaction contributes to higher structural stability and longevity of NFRCs..

9. CONCLUSIONS

In conclusion, this study successfully investigated the potential of kenaf fiber as a sustainable reinforcement material for improving the mechanical properties of natural fiber-reinforced composites in automotive door panels. The

results demonstrated that kenaf fiber-reinforced composites exhibit enhanced mechanical properties, making them a viable substitute for petroleum-based materials. By utilizing kenaf fiber, a sustainable and eco- friendly resource, the automotive industry can reduce its environmental footprint and contribute to a circular economy. The findings of this study pave the way for the development of lightweight, sustainable, and high- performance automotive components, aligning with the industry's shift towards environmentally responsible practices. Furthermore, the use of kenaf fiber can help reduce greenhouse gas emissions, promote sustainable resource circulation, and support the development of eco- friendly automotive products. The study's outcomes also highlight the potential of kenaf fiber-reinforced composites to replace traditional materials in various automotive applications, leading to a more sustainable and environmentally friendly transportation sector. Overall, this study contributes to the advancement of sustainable composite materials for automotive applications, providing a valuable foundation for future research and development in this area.

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