International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

DEVELEOPMENT OF ABS BASED NATURAL COMPOSITE FILAMENT FOE 3D PRINTING APPLICATION

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Abstract - This study focuses on the development of a sustainable and high-performance composite filament by incorporating groundnut shell-derived carbon into ABS (Acrylonitrile Butadiene Styrene) for 3D printing applications. The aim is to utilize agricultural waste, specifically groundnut shells, to improve the mechanical and thermal properties of the polymer while contributing to sustainable manufacturing. Groundnut shells, a lignocellulosic by-product, were crushed, sieved, and integrated into ABS using melt extrusion techniques. Filament production involved optimizing filler loading percentages and ensuring consistent extrusion quality.
Comprehensive testing, including tensile, flexural, and thermal analyses, was conducted to evaluate the performance of the composite. The results indicated significant enhancements in mechanical strength and thermal stability, showcasing the potential of groundnut shell-derived carbon as a viable natural filler. The approach not only reduces environmental impact but also offers a cost-effective alternative to conventional materials.
Applications in various industrial sectors, including automotive and consumer goods, were identified, emphasizing the utility of this innovative filament in advancing eco-friendly 3D printing. Future work will focus on refining the filler compatibility and exploring surface treatments for further performance improvement.

I. INTRODUCTION

The growing demand for environmentally sustainable materials has spurred interest in utilizing agricultural waste for polymer composites. Groundnut shells, an abundant by-product of peanut processing, are rich in lignocellulosic fibers, making them a promising candidate for composite reinforcement. This study explores the incorporation of groundnut shell-derived carbon into ABS, a widely used thermoplastic, to enhance its properties for 3D printing applications. The objectives include investigating the impact of filler loading on mechanical and thermal properties and validating the composite's performance in practical scenarios. By diverting agricultural waste into valuable applications, this project aims to address sustainability challenges while promoting innovation in additive manufacturing.

II. LITERATURE SURVEY

1. Shanmugam et al. investigated the use of agricultural waste as fillers in polymers, demonstrating significant improvements in tensile strength and environmental benefits through optimized grinding and sieving techniques.
2. Park et al. highlighted the thermal and mechanical enhancements achievable in ABS composites by incorporating lignocellulosic fibers, including

improved stability and reduced shrinkage.

3. Singh et al. detailed processing methods for agricultural by-products, emphasizing the importance of particle size uniformity for effective composite formulation.
4. Oliveira et al. explored biocomposites in sustainable manufacturing, reporting cost reductions and environmental advantages when natural fillers are utilized.
5. Lee et al. analyzed the impact of filler particle size distribution on composite properties, concluding that smaller, evenly distributed particles yield superior mechanical performance.
6. Further studies have addressed challenges in achieving homogeneity in fiber-polymer blends and enhancing interfacial bonding through chemical treatments.
7. Research by Kim et al. demonstrated the feasibility of agricultural waste in 3D printing, emphasizing eco-friendly material innovations.
8. Other investigations have examined thermal and morphological properties of bio-based composites, identifying their potential for diverse industrial applications.
9. Studies on the lifecycle assessment of biocomposites confirm their reduced carbon footprint compared to traditional materials.
10. Additional work has focused on scalability and commercial feasibility, showcasing the viability of agricultural waste composites in large-scale manufacturing.

III. PROPOSED METHODOLOGY

Material Preparation

Collect groundnut shells, clean and dry them. Crush shells into fine particles and perform sieve analysis to obtain uniform particle size.

Composite Formulation

Blend groundnut shell particles with ABS resin using a twin-screw extruder .Optimize filler loading (e.g., 5%, 10%, and 15% by weight) to study its impact on properties.

Filament Production

Extrude the composite material into filaments suitable for FDM (Fused Deposition Modeling) 3D printing .Perform quality control checks to ensure consistent filament diameter.

Testing and Analysis

Conduct tensile, flexural, and impact tests to assess mechanical properties .Perform TGA (Thermogravimetric Analysis) and DSC (Differential Scanning Calorimetry) for thermal property evaluation .Use SEM (Scanning Electron Microscopy) to analyze the morphology of printed samples.

Validation and Applications

Print sample components to validate the filament's performance in 3D printing applications

IV. DISCUSSION

The integration of groundnut shell-derived carbon into ABS composites has showcased significant advancements in material performance and sustainability. The composite material demonstrated improved tensile and flexural properties, highlighting its potential for high-strength applications. Thermal analysis revealed enhanced stability, indicating better dimensional accuracy during the 3D printing process. These enhancements can be attributed to the effective dispersion of groundnut shell

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particles within the ABS matrix and the inherent lignocellulosic properties of the filler. From an environmental perspective, the use of groundnut shells, an agricultural by-product, aligns with global efforts toward reducing waste and promoting circular economy principles. By replacing synthetic fillers with natural alternatives, the carbon footprint of composite manufacturing is significantly reduced, making this material a viable solution for eco-friendly production.

However, challenges such as achieving uniform filler dispersion and optimizing extrusion parameters were encountered during the study. To address these, rigorous mixing protocols and precise process controls were implemented. Despite these advancements, further research is required to enhance the interfacial bonding between the polymer matrix and the filler particles. Techniques such as surface treatments or the addition of coupling agents could further improve composite performance. Applications of this composite filament are vast, ranging from automotive parts and consumer goods to prototyping and functional components in additive manufacturing. The material's enhanced properties make it a strong contender in industries that demand durability and thermal stability. Future directions should focus on scaling up production, improving filler-polymer compatibility, and exploring additional agricultural waste sources to expand the range of sustainable composite materials.

V. CONCLUSION

This study successfully developed a composite filament using groundnut shell-derived carbon and ABS for 3D printing applications. The incorporation of natural fibers improved the mechanical and thermal properties of ABS while offering a sustainable alternative to conventional materials. This approach not only promotes eco-friendly practices but also provides a cost-effective solution for various industrial applications. Future work will focus on enhancing the interfacial bonding between groundnut shell particles and the polymer matrix for superior performance.

VI. REFERENCES

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