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PST009 - ECOFUSION: SUSTAINABLE COMPOSITES FROM RECYCLED PLASTICS AND WATER HYACINTH FIBRES

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ABSTRACT

Ecofusion introduces an innovative, scalable solution to two pressing environmental challenges: plastic pollution and invasive water hyacinth (WH) overgrowth. Sustainable and good performance composites was fabricated by reinforcing recycled low-density polyethylene and recycled linear low density polyethylene (rLDPE/rLLDPE) with treated water hyacinth fibres (WHF). This project's core innovation is its pioneering dual-waste valorization approach, directly addressing ecological concerns while simultaneously creating a new class of functional composite materials; turning waste into wealth. WHF was chemically treated using 5 wt% NaOH to optimize interfacial bonding, and was further blended with rLDPE/rLLDPE at 5%, 10%, and 15% loadings. Rigorous testing revealed an increased in tensile strength peaking at 18.02 MPa with 10% WHF and a maximum Young's modulus of 352 MPa at 15% WHF, signifying enhanced stiffness. The increased in WHF loadings had also increased the impact strength, density and hardness of the composites. Fourier Transform Infrared (FTIR) analysis confirmed robust chemical interactions, ensuring material integrity despite WHF's inherent hydrophilicity. These cost-effective and scalable biocomposites demonstrate versatile applicability in areas such as eco-friendly packaging, lightweight automotive panels, and durable construction materials. Ecofusion represents a significant leap towards circular economy practices, offering a pragmatic and profitable pathway to mitigate plastic waste and manage aquatic biomass, delivering both ecological restoration and industrial advancement. This is a game-changer for sustainable materials.

Keywords – Sustainable composites, water hyacinth fiber, recycled polyethylene, green materials

INTRODUCTION

The proliferation of non-biodegradable plastic waste, particularly polyethylene (PE), and the uncontrolled growth of invasive WH pose significant, dual environmental challenges. PE waste contributes to long-term pollution, while WH clogs waterways, disrupts ecosystems, and creates waste management problems. Addressing the drawbacks of recycling PE, such as reduced mechanical quality compared to virgin polymers, is a primary motivation for this project. Therefore, this study aims to address both problems simultaneously by developing a novel composite material. By integrating treated WHF, a low-cost and renewable resource rich in cellulose, with rLDPE/rLLDPE, this project seeks

to enhance the mechanical properties of the recycled plastic and valorize two waste streams into a sustainable and valuable material.

This dual-waste valorization approach not only mitigates environmental pollution but also promotes the principles of a circular economy.

OBJECTIVE

The objective of this product is to develop and characterize the physicomechanical properties of sustainable composite materials from recycled polyethylene PE waste and invasive WHFs thereby offering an eco-friendly and economically viable solution to two critical environmental challenges.

DESCRIPTION OF THE PROJECT

Ecofusion composites are novel, eco-friendly materials produced from two abundant waste streams which are blends of post-consumer/industrial rLDPE/rLLDPE and treated lignocellulosic WHF. WHF loadings were optimized between 5% and 15%. The ecofusion composites exhibit improved tensile strength and significantly increased stiffness/Young's modulus compared to virgin PE or unreinforced recycled PE. Enhanced adhesion between the hydrophilic WHF and the hydrophobic PE matrix were achieved through a proprietary 5 wt% NaOH treatment, ensuring efficient stress transfer between fibers and the polymer matrix.

Therefore, it can be inferred that the mechanical properties can be tailored by adjusting WHF content, allowing for optimization based on specific application requirements. This project also retains the ease of processing characteristic of thermoplastics, allowing for fabrication using standard methods like melt blending, extrusion, and injection molding. The composites produced is capable of withstanding significant tensile and impact loading, making them suitable for semi-structural applications. The incorporation of WHF imparts increased rigidity, crucial for applications requiring dimensional stability and resistance to deformation under load. While natural fibers are generally hydrophilic, the improved interfacial bonding also helps to mitigate excessive water absorption, enhancing durability in various environments.

The advantage of this project also helps to reduce the demand for virgin petroleum-based plastics and offers a sustainable alternative to traditional fillers, conserving non-renewable resources. Besides, the utilization of inexpensive and abundant waste materials, leading to potentially lower production costs compared to composites made with synthetic fibers or virgin polymers. The commercialization of WH plant into useful products could provides potential opportunities for local communities involved in harvesting and pre-processing water hyacinth, fostering local economies.

Figure 1: The ecofusion composites production process

NOVELTY

The primary novelty of "ecofusion" lies in its pioneering dual-waste valorization approach, which uniquely addresses two pervasive environmental pollutants; non-biodegradable PE plastic waste and invasive WH biomass, by transforming them into high-performance, sustainable composite materials. Unlike approaches that tackle these problems in isolation, this project presents an integrated, closed-loop solution that simultaneously reduces landfill burden and manages aquatic overgrowth. The project demonstrates a cost-effective and industrially scalable method for producing these biocomposites. Utilizing abundant and often problematic waste materials as raw inputs significantly reduces material costs, making the end product economically attractive for various industries.

CONCLUSION

Ecofusion had successfully turns two waste problems which are plastic pollution and invasive WH into a single solution. By combining recycled plastic with treated WHFs, the project created a strong and stiff new composite material. This approach not only cleans up the environment but also provides a cost-effective way to make new products for industries like packaging and construction, proving that waste can be a valuable resource in a circular economy.