Seshat's Bones: A Fully Hemp-Based Epoxy Composite Hypothesized to Outperform Petroleum Composites, Plastics, and Metals

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Abstract

This paper proposes a novel hemp-based composite—*Seshat's Bones*—formulated from epoxidized hemp oil, chemically modified hemp lignin, and reinforced with hemp-derived carbon allotropes (biochar and nanosheets). The hypothesis is that this composite can surpass petroleum-based plastics and metals in mechanical, thermal, and dielectric performance, while also being biodegradable, ethical, and sustainable. The study outlines supporting research, experimental design, and predictive modeling to validate this high-performance green nanocomposite.

1. Introduction

There is an urgent need to replace petroleum-based materials due to environmental and energy concerns. Hemp (*Cannabis sativa*) is a sustainable alternative due to its rapid growth, low resource needs, and diverse chemical constituents. This study presents *Seshat's Bones*, a fully hemp-based composite combining epoxidized hemp oil, modified lignin, and carbon-rich reinforcements, aiming to set a new standard in sustainable materials.

2. Observation and Problem Statement

Conventional composites rely on synthetic resins and metals with high embodied energy and poor recyclability. Although bio-composites exist, they often fail to meet engineering standards. *Seshat's Bones* aims to overcome these limitations with a 100% hemp-derived formulation that can rival or outperform conventional materials.

3. Research Question

Can a composite made solely from hemp derivatives outperform petroleum-based composites, plastics, and select metals in mechanical, thermal, and dielectric performance?

4. Hypothesis

A synergistic integration of:

- Epoxidized hemp oil (resin base)
- Chemically modified hemp lignin (matrix stiffener)
- Hemp biochar and nanosheets (reinforcements)

will yield a composite with exceptional mechanical strength, thermal resistance, and tunable dielectric properties, while maintaining biodegradability and ethical sourcing.

5. Background and Literature Review

- **Epoxidized Plant Oils**: Demonstrated success in producing biodegradable thermosets, though typically weaker than petroleum epoxies.
- **Lignin**: Enhances rigidity and fire resistance; modifiable for better matrix integration.
- **Biochar**: Provides stiffness, carbon sequestration, and high-temperature stability.
- **Nanosheets**: Improve strength, toughness, and dielectric properties.

No existing composite unites all these hemp-based elements. *Seshat's Bones* proposes this integration as a world-first.

6. Experimental Design

6.1 Materials

- Cold-pressed hemp oil for epoxidation
- Organosolv-processed hemp lignin
- Biochar produced at 500–700°C
- Hemp-derived nanosheets (ultrasonically exfoliated)
- Bio-based amine curing agents

6.2 Synthesis Steps

1. Epoxidize hemp oil using hydrogen peroxide and acetic acid
2. Modify lignin with maleic anhydride
3. Disperse biochar and nanosheets via ultrasonication
4. Mix with lignin and curing agent
5. Mold and cure thermally (80–150°C)

7. Predicted Results

- **Mechanical**: Strength-to-density ratio expected to exceed ABS and approach aluminum.
- **Thermal**: Degradation onset above 350°C; glass transition temperature over 100°C.
- **Dielectric**: Tunable permittivity through nanosheet concentration control.

8. Analysis Plan

- **FTIR & NMR**: Confirm epoxidation and lignin integration.
- **TGA & DSC**: Measure thermal stability and curing profile.
- **SEM & TEM**: Assess dispersion and interfacial bonding.
- **Tensile and Flexural Tests**: ASTM standards.
- **Dielectric Spectroscopy**: Frequency-dependent permittivity.

9. Discussion

Success would mark a turning point in sustainable engineering. The material could replace petroleum-based plastics and metals in sectors like aerospace, defense, and electronics. Even if performance falls short, insights would refine the next generation of biocomposites.

10. Conclusion

Seshat's Bones introduces a groundbreaking organic material platform. Fully hemp-based and scalable, it promises performance rivaling the best synthetic materials with none of the environmental cost. If validated, it could help establish a circular, resilient, and ethically grounded materials economy.

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