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

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Abstract

We introduce a paradigm-shifting hypothesis: **A fully hemp-based epoxy composite—formulated from epoxidized hemp oil and chemically modified hemp lignin, and reinforced with hemp-derived carbon allotropes (biochar and nanosheets)—can hypothetically outperform petroleum-based composites, synthetic plastics, and metals in mechanical, thermal, and dielectric performance, while remaining sustainable, biodegradable, and ethically sourced.** This paper applies the full scientific method to this hypothesis, including prior research review, experimental design, proposed validation protocols, and predictive modeling frameworks for sustainable nanocomposite innovation.

1 1. Introduction

The need for sustainable, high-performance materials is driving rapid innovation in green nanocomposites. Petroleum-based thermosets, thermoplastics, and even metals contribute to environmental degradation, resource depletion, and toxic waste. Hemp, a regenerative biomass crop, offers a unique convergence of material potential: oil-rich seeds, lignin-rich stalks, and carbon-dense biochar and nanosheets. This study proposes a new class of bio-epoxy composites—Seshat's Bones—that integrates all these components into a single, fully organic platform.

2 2. Observation and Problem Statement

Conventional composite systems rely heavily on synthetic resins (e.g., bisphenol-A epoxy), inorganic reinforcements (e.g., carbon or glass fibers), and extractive resources (e.g., metals). These systems have high embodied energy and limited recyclability. Organic composites offer environmental benefits but often fall short in performance. This study seeks to overcome that gap.

3 3. Research Question

Can a composite made entirely from hemp derivatives outperform petroleum-based composites, plastics, and select metals in key engineering domains?

4 4. Hypothesis

A fully hemp-based epoxy composite—formulated from epoxidized hemp oil and chemically modified hemp lignin, and reinforced with hemp-derived carbon allotropes (biochar and nanosheets)—can hypothetically outperform petroleum-based composites, synthetic plastics, and metals in mechanical, thermal, and dielectric performance, while remaining sustainable, biodegradable, and ethically sourced.

5 5. Background and Literature Review

Numerous studies support the potential of:

- Epoxidized plant oils as green thermosets [3, 4]
- Lignin as a functional, aromatic crosslinker [1, 5]
- Biochar as a reinforcement improving thermal and structural stability [2]
- Nanosheets from biomass for dielectric and mechanical enhancement

Yet no published system has combined all hemp-based components into a single composite platform with demonstrated superiority over synthetic and metallic competitors.

6 6. Experimental Design

6.1 6.1 Materials

- Hemp oil (cold-pressed)
- Hydrogen peroxide, sulfuric acid, acetic acid (epoxidation reagents)
- Hemp lignin (organosolv processed)
- Hemp biochar (500–700°C pyrolyzed)
- Hemp nanosheets (ultrasonically exfoliated)

6.2 6.2 Synthesis Steps

1. Epoxidize hemp oil following Goud et al. protocol [3].
2. Modify lignin with maleic anhydride for hydroxyl enrichment.
3. Disperse biochar and nanosheets into resin via ultrasonication.

4. Mix with lignin and amine curing agent.
5. Cast into molds and thermally cure (80–150°C).

7 7. Predicted Results

Based on literature data and known synergies:

- **Mechanical:** Specific strength and modulus exceeding ABS and on par with aluminum.
- **Thermal:** Degradation onset above 350°C; Tg above 100°C.
- **Dielectric:** Tunable permittivity via nanosheet concentration; biodegradable substrates for circuits.

8 8. Analysis Plan

Post-synthesis, we will conduct:

- **FTIR, NMR** for chemical structure confirmation
- **TGA/DSC** for thermal stability and glass transition
- **SEM/TEM** for dispersion quality and interface analysis
- **Tensile, flexural tests** for mechanical performance
- **Dielectric spectroscopy** for electronic properties

9 9. Discussion

Success would validate a new class of bio-based materials capable of replacing petroleum and metal systems in applications ranging from automotive and defense to sustainable electronics and space infrastructure. Failure would provide insights into processing limits, dispersion challenges, or chemical incompatibilities.

10 10. Conclusion

If confirmed experimentally, Seshat's Bones represents a step-change in organic material science: a biodegradable, scalable, and high-performance composite system that aligns with circular economy goals, ethical sourcing, and ecological sovereignty.

References

References

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