Seshat's Bones: A Hemp-Based Epoxy Composite Reinforced with Hemp Carbon Allotropes

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June 2, 2025

Abstract

We present **Seshat's Bones**, an innovative bio-epoxy matrix derived entirely from hemp-based feedstocks: epoxidized hemp oil, reactive hemp lignin, and reinforced with hemp biochar and nanosheets. This high-performance, sustainable composite is designed for advanced industrial and defense applications. Integrating all-organic components, this system exemplifies the principles of the Organic Revolution and establishes a new class of materials for ethical, circular manufacturing.

1. Introduction

The search for sustainable, high-performance materials has led to the exploration of plant-based epoxy resins and composites. Hemp oil, a triglyceride rich in unsaturated fatty acids, can be chemically epoxidized to form a renewable thermoset matrix. Hemp lignin, an aromatic biopolymer extracted from stalk waste, provides both crosslinking potential and rigidity.

To further enhance the mechanical, thermal, and electrical properties, we introduce **Seshat's Bones**: a formulation incorporating hemp-derived carbon allotropes—biochar and nanosheets—into the epoxy-lignin matrix. This novel composite positions itself as an organic, biodegradable alternative to petroleum-based thermosets and carbon-reinforced composites.

2. Materials and Methods

Reagents.

- Hemp seed oil (cold-pressed, filtered)
- Hydrogen peroxide (30%)
- Acetic or formic acid

- Sulfuric acid (catalyst)
- Sodium bicarbonate, magnesium sulfate
- Hemp lignin (organosolv preferred)
- Curing agent (e.g., triethylenetetramine)
- Hemp biochar (carbonized hemp stalks)
- Hemp nanosheets (exfoliated from pyrolyzed hemp cellulose)

Equipment.

- Three-neck flask with reflux condenser
- Mechanical stirrer, dropping funnel
- Separatory funnel, ultrasonicator
- FTIR, NMR, SEM/TEM, TGA/DSC instruments
- Thermal curing oven or press

3. Synthesis Procedure

3.1. 1. Epoxidation of Hemp Oil.

1. Combine 100 mL hemp oil and 100 mL acetic acid in a 3-neck flask.
2. Heat to 50 °C with stirring.
3. Slowly add 70 mL of 30% H_2O_2 dropwise over 1 hour.
4. Add 1 mL sulfuric acid as catalyst; maintain at 60 °C for 5 hours.
5. Cool, wash with $NaHCO_3$ and brine, dry over $MgSO_4$.
6. Confirm epoxidation via FTIR (peaks at 820–860 cm^{-1}).

3.2. 2. Lignin Preparation.

- Dry hemp lignin under vacuum at 60 °C.
- Optionally modify with maleic anhydride or propylene oxide to increase hydroxyl content.
- Sieve to obtain fine reactive powder.

3.3. 3. Seshat's Bones Composite Fabrication.

1. Disperse hemp biochar (10–20% w/w) and nanosheets (0.5–5% w/w) into the epoxidized hemp oil using ultrasonication.
2. Add lignin (20–30% w/w relative to resin) and curing agent.
3. Mix at 60 °C for 30 minutes to ensure homogeneity.
4. Pour into molds and cure at 80–150 °C for 2–6 hours.

4. Characterization

FTIR.

- Epoxy peak: 820–860 cm^{-1}
- Disappearance of alkene C=C: 3010 cm^{-1}

NMR.

- ^{1}H NMR: Disappearance of vinylic protons, emergence of oxirane signals.
- $^{1}_{3}C$ NMR: New epoxy carbon signals at 44–52 ppm.

TGA/DSC.

- TGA onset degradation temperature: 340–400 °C
- Glass transition temperature (T_g): 85–110 °C

SEM/TEM.

- Confirm uniform dispersion of biochar and nanosheets in matrix.
- Identify interfacial adhesion between carbon phase and resin.

5. Discussion

The synergistic use of hemp oil, hemp lignin, and hemp carbon allotropes produces a fully bio-based thermoset with significantly enhanced properties:

- **Biochar** adds thermal resistance, dimensional stability, and rigidity.
- **Nanosheets** improve barrier properties, tensile strength, and conductivity.
- **Lignin** ensures crosslinking and rigidity with a bio-aromatic backbone.

This configuration can be tuned for mechanical optimization, biodegradability, or fire performance. The resulting composite may be applied in ballistic armor, electronic dielectrics, green construction, and aerospace bio-composites.

6. Applications

- **Seshat's Composites**: Load-bearing structural panels.
- **Ballistic Defense**: Hemp-carbon reinforced armor plates.
- **Eco-Circuit Boards**: Bio-dielectric substrates with nanosheet conductivity.
- **Organic Infrastructure**: Components for New Pyramids, MissionSahara, and Space Habitats.

7. Conclusion

Seshat's Bones exemplifies a novel, circular economy solution built entirely from hemp. It represents a paradigm shift in composite material design—merging epoxidized plant oils, reactive lignin, and biomass-derived carbon allotropes into one sustainable, scalable platform. This innovation directly supports organic sovereignty, sustainable defense, and the Universal Declaration of Organic Rights.

References

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