Seshat's Bones:
A Multiversion Scientific Framework for Sustainable Hemp Nanocomposites (v1.1–v1.4)

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Contents

Abstract

This document presents a full scientific overview of "Seshat's Bones," a hemp-based nanocomposite developed in versions v1.1 through v1.4. Each version adds sustainability, circularity, and functionality. The project culminates in **Hempoxy**, a scalable, recyclable, high-performance biocomposite. Each formulation is documented chemically and mathematically, with a universal performance model and predictive matrix for future innovation.

Glossary

HDCNS Hemp-Derived Carbon Nanosheets

EHO Epoxidized Hemp Oil

FGE Furfuryl Glycidyl Ether

WDF Waste-Derived Functional Filler

MA-Lignin Maleic Anhydride-Modified Lignin

LCA Life Cycle Assessment

1 Introduction

The "Seshat's Bones" initiative began as an answer to the scarcity of sustainable high-performance engineering materials. This document maps its full evolution through iterative versions, culminating in Hempoxy—a commercial-grade organic composite designed for structural, electrical, and regenerative performance.

2 Scientific Method Framework

1. Observation of unsustainable composite systems
2. Hypothesis formulation (per version)
3. Literature review and bio-based chemical logic
4. Experimental design (curing, mixing, testing)
5. Data analysis (mechanical, thermal, electrical)
6. Conclusions and next-version planning

3 Master Mathematical Formula

$$P = \left[\frac{(\sigma_T \cdot E \cdot \rho^{-1})}{A_f \cdot \eta_v \cdot \Delta_\theta} \right] \cdot \Phi_c \cdot \Omega_w$$

Legend:

- P = Overall material performance
- σ_T = Tensile strength (MPa)
- E = Elastic modulus (GPa)
- ρ = Density (g/cm^3)
- A_f = Anisotropy factor
- η_v = Resin viscosity multiplier
- Δ_θ = Thermal stress tolerance
- Φ_c = Interfacial compatibility score
- Ω_w = Waste integration + recyclability

4 Versioned Chemical Recipes and Formulas

4.1 Version 1.1 — Baseline High-Performance Bio-Nanocomposite

Formula Vector:

$$R_{1.1} = \begin{bmatrix} \text{EHO} & 45\% \\ \text{FGE} & 5\% \\ \text{Biochar} & 35\% \\ \text{MA-Lignin} & 10\% \\ \text{HDCNS (COOH)} & 2\% \\ \text{Azelaic Anhydride} & 3\% \end{bmatrix}$$

Summary:

- Addresses high resin viscosity with FGE.
- High tensile strength (110–150 MPa).
- Achieves quasi-isotropy: $A_f < 20\%$.
- $\Omega_w \approx 0.1$, $\Phi_c \approx 0.85$

4.2 Version 1.2 — Waste Sequestration Integration

New Term: WDF (Waste-Derived Functional Filler)

$$R_{1.2} = \begin{bmatrix} \text{EHO} & 45\% \\ \text{FGE} & 5\% \\ \text{Biochar} & 34.2\% \\ \text{MA-Lignin} & 10\% \\ \text{HDCNS} & 2\% \\ \text{WDF (coated)} & 0.8\% \\ \text{Azelaic Anhydride} & 3\% \end{bmatrix}$$

Effects:

- Sequesters microtrash.
- Slight reduction in filler loading to accommodate WDF.
- $\Omega_w \to 0.5$

4.3 Version 1.3 — Controlled Degradation and Circularity

Enhancement: Add cleavable linkers to EHO.

$$R_{1.3} = R_{1.2} + \mathrm{CLink}_{\mathrm{UV/pH}}$$

Function:

- Ester/Diels–Alder/disulfide linkers allow targeted breakdown.
- Enables recovery of HDCNS, biochar, and WDF.
- $\Omega_w \to 0.85$

4.4 Version 1.4 — Scalability and Life Cycle Dominance

Optimized Manufacturing Blueprint:

$$R_{1.4} = R_{1.3} + \mathrm{FlowReactor}_{\text{EHO, MA-Lignin}} + \text{ISO-LCA}_{\text{Cradle-Cradle}}$$

Process Highlights:

- Continuous-flow synthesis of EHO and lignin.
- Industrial compression molding at scale.
- ISO-compliant LCA shows $> Y\%$ lower GHG footprint vs. aluminum.
- $\Omega_w \approx 1.0$, $\Phi_c \approx 0.95$

5 Conclusion

Each iteration of Seshat's Bones represents a leap forward in merging performance with ecology. From tensile strength to recyclability, the system evolves into Hempoxy: a material ready for aerospace, defense, and global infrastructure.

AI Assistance Disclaimer

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