Scientific Research Proposal: Seshat's Bones v1.3 (Controlled Degradation and Recyclability Variant)

Marie Seshat Landry
Marie Landry's Spy Shop marielandryceo.blogspot.com
Global Organic Solutions

July 9, 2025

Executive Summary

This proposal outlines the scientific investigation for "Seshat's Bones v1.3," aiming to complete the circular economy for this advanced biocomposite. Building upon the high-performance and waste-sequestration capabilities of prior versions, v1.3 introduces controlled degradation and enhanced recyclability. The central hypothesis posits that by strategically incorporating specific cleavable linkers into the Epoxidized Hemp Oil matrix, the composite can be designed to degrade upon targeted triggers, allowing for the recovery and re-use of its valuable constituent materials, while maintaining its integrity and functionality throughout its service life. This research seeks to create a material that is not only sustainably sourced and actively remediates waste during use, but also offers a responsible and resource-efficient end-of-life solution.

Contents

1 Introduction: Completing the Circular Economy for Advanced Biocomposites

Building upon the successes of "Seshat's Bones v1.1" (high-performance, quasi-isotropic nanocomposite from *Cannabis Sativa L.*) and "v1.2" (incorporating waste sequestration), "Seshat's Bones v1.3" aims to address the critical challenge of end-of-life management for advanced composites. While existing versions prioritize sustainable sourcing and active environmental remediation during use, the long-term impact and resource efficiency are further enhanced by designing for controlled degradation and recyclability. Current high-performance composites, even bio-based ones, often pose significant disposal challenges due to their robust nature. This variant seeks to close the material loop, offering a truly cradle-to-cradle solution.

2 Historical Formulations: Seshat's Bones v1.1 and v1.2

To provide context for the evolution of the "Seshat's Bones" composite, the full formulations for versions v1.1 and v1.2 are presented below. These earlier iterations laid the groundwork for the high-performance and waste-sequestration capabilities that v1.3 now seeks to make degradable and recyclable.

"Seshat's Bones v1.1" Proposed Formulation (Reference)

- **Part A:**
  - **Epoxidized Hemp Oil (EHO):** 45% by Weight – Primary bio-based polymer matrix
  - **Furfuryl Glycidyl Ether (FGE):** 5% by Weight – Reactive diluent for viscosity reduction
  - **Pyrolyzed Hemp Biochar:** 35% by Weight – Micro-filler for reinforcement and bulk properties
  - **Maleic Anhydride-Modified Hemp Lignin:** 10% by Weight – Bio-interfacial agent for improved adhesion
  - **Carboxyl-Functionalized HDCNS:** 2% by Weight – Nano-reinforcement and electrical conductivity
- **Part B:**
  - **Azelaic Anhydride:** 3% by Weight – Hardener for cross-linking and curing

"Seshat's Bones v1.2" Proposed Formulation (Reference)

- **Part A:**
  - **Epoxidized Hemp Oil (EHO):** 45% by Weight – Primary bio-based polymer matrix

  - **Furfuryl Glycidyl Ether (FGE):** 5% by Weight – Reactive diluent for viscosity reduction
  - **Pyrolyzed Hemp Biochar:** 34.2% by Weight – Micro-filler for reinforcement and bulk properties
  - **Maleic Anhydride-Modified Hemp Lignin:** 10% by Weight – Bio-interfacial agent for improved adhesion
  - **Carboxyl-Functionalized HDCNS:** 2% by Weight – Nano-reinforcement and electrical conductivity
  - **Waste-Derived Functional Filler (WDF):** 0.8% by Weight – Waste sequestration and compatible filler
- **Part B:**
  - **Azelaic Anhydride:** 3% by Weight – Hardener for cross-linking and curing

3 Formulating the New Scientific Challenge for Seshat's Bones v1.3

The central scientific challenge for "Seshat's Bones v1.3" is:

- How can the "Seshat's Bones" composite be designed to undergo controlled degradation upon specific triggers (e.g., pH change, enzymatic activity, specific wavelength light, or thermal stimulus) while retaining its high mechanical performance and waste-sequestration capabilities during its intended service life, and subsequently allow for the recovery and re-use of its constituent materials?

This challenge requires careful selection and integration of smart functional elements that enable reversible bonding or controlled cleavage of the polymer matrix, without compromising the overall material integrity or the encapsulated waste's stability until activated.

4 The "Seshat's Bones v1.3" Hypothesis

"If specific photo-cleavable, thermally sensitive, or enzymatically labile linkers are strategically incorporated into the Epoxidized Hemp Oil (EHO) matrix during the curing process, and these linkers are designed to activate only under targeted environmental triggers, then 'Seshat's Bones v1.3' will demonstrate controlled degradation behavior, allowing for the recovery of valuable components (including sequestered waste) for recycling or safe environmental assimilation, while maintaining the material's high mechanical performance and waste sequestration efficacy throughout its service life."

5 Proposed Enhancements for "Seshat's Bones v1.3"

To achieve controlled degradation and recyclability, "Seshat's Bones v1.3" would involve:

- **Matrix Modification:**

  - **Cleavable Linkers:** Introducing reversible covalent bonds or cleavable linkages (e.g., Diels-Alder adducts, disulfide bonds, or ester linkages) within the EHO polymer network that can be broken by specific external stimuli (heat, pH, light, enzymes).
  - **Trigger Mechanisms:** Research into specific "smart" molecules or additives that act as catalysts or initiators for the degradation process upon activation.

- **Selective Degradation Pathways:**
  - Designing the degradation to primarily target the polymer matrix, allowing for the potential separation and recovery of the carbon nanosheets, biochar, and especially the sequestered Waste-Derived Functional Filler (WDF).

- **Recycling Protocol Development:**
  - Devising and optimizing methods for the physical or chemical separation of components post-degradation, enabling their reintroduction into new composite formulations or other material streams.

6 Anticipated Performance Predictions for "Seshat's Bones v1.3"

- **Tensile Strength & Specific Strength:** Retain 90-120 MPa tensile strength and comparable specific strength to v1.2, demonstrating that reversible bonds do not significantly compromise in-service performance.
- **Controlled Degradation Rate:** Demonstrate a tunable degradation rate (e.g., X% mass loss per Y hours) under specified trigger conditions.
- **Component Recovery Rate:** Achieve Z% recovery of primary fillers (HDCNS, biochar) and sequestered WDF for reprocessing.
- **Re-processability:** Successfully integrate recovered materials into new "Seshat's Bones" composites, retaining a minimum of W% of original properties.

7 Key Experimental Considerations

- **Synthesis of Labile Monomers/Linkers:** Developing or sourcing specific molecules that can be integrated into the EHO matrix and cleaved on demand.
- **Degradation Kinetics Studies:** Thorough investigation of the degradation rates under various trigger conditions (temperature, pH, UV exposure, enzyme concentration).
- **Recovered Material Characterization:** Detailed analysis of the recovered components to assess their purity and suitability for re-use.
- **Recycled Composite Performance:** Evaluation of mechanical, physical, and functional properties of composites made with recycled components to confirm viable closed-loop recycling.

This "Seshat's Bones v1.3" variant would position the material as a leading example of truly sustainable engineering, offering high performance during its lifespan and responsible management at its end-of-life.