Master Hypothesis for the Seshat's Bones Project

It is hypothesized that a high-performance, **monolithic** and **isotropic nanocomposite** can be synthesized entirely from a *Cannabis sativa L.* feedstock by strategically integrating key components to achieve a fully **circular economy**.

This is achieved by formulating a bio-epoxy matrix derived from **Epoxidized Hemp Oil (EHO)** that is cross-linked and hardened with a **Maleic Anhydride-Modified Lignin (MA-Lignin)**. The MA-Lignin is specifically designed to function as a **bio-compatible interfacial agent**, ensuring that a hierarchical system of **Hemp-Derived Carbon Nanosheets (H-CANs)** and pyrolyzed hemp biochar can be uniformly dispersed to create a cohesive and manufacturable composite paste. This process will ultimately yield a solid with uniform properties in all directions.

Furthermore, this core formulation can be enhanced to achieve a full circular economy by integrating:

1. **Waste-Derived Functional Fillers (WDFs)** to permanently sequester pollutants, such as microplastics and Styrofoam, within the composite's structure.
2. An **Optional Degradation Module** containing **cleavable linkers**, such as **Furfuryl Glycidyl Ether (FGE)**, which will enable controlled degradation on-demand, allowing for the recovery and reuse of the material's constituent components.

The resulting multi-functional material, Hempoxy, is predicted to possess performance characteristics (including tensile strength, stiffness, and density) that are competitive with, or superior to, traditional petroleum-based and metallic materials, thereby establishing a new standard for sustainable engineering.

Glossary of Key Terms

- **Monolithic:** A material that is cast or formed as a single, uniform block without joints or seams, providing greater structural integrity.
- **Isotropic:** A material with physical properties that are the same in all directions. This is a key departure from traditional fiber composites, which are often stronger in one direction than another.
- **Nanocomposite:** A material composed of a matrix reinforced with particles that have at least one dimension in the nanoscale (1-100 nanometers).
- **Bio-compatible Interfacial Agent:** A substance (in this case, MA-Lignin) that helps different organic materials—like the hemp oil matrix and the carbon fillers—bond together effectively at a molecular level. It's what makes the "paste" consistent and workable.

- **Cleavable Linkers:** Specific chemical bonds that can be broken by a targeted trigger (e.g., heat, a specific solvent). This is the mechanism for the material's controlled degradation.
- **Circular Economy:** An economic system aimed at eliminating waste and the continual use of resources. In this project, it means the material can be recovered and reused instead of being discarded in a landfill.
- **Epoxidized Hemp Oil (EHO):** Hemp oil that has been chemically modified to be used as a thermoset resin, forming the "epoxy" part of the composite.
- **Hemp-Derived Carbon Nanosheets (H-CANs):** Carbon sheets at the nanoscale, derived from hemp, that act as the primary reinforcing filler.
- **Maleic Anhydride-Modified Lignin (MA-Lignin):** Lignin, a natural polymer from hemp, that has been modified to act as a hardener and interfacial agent.
- **Waste-Derived Functional Fillers (WDFs):** Upcycled waste materials, such as microplastics, that are deliberately added to the composite for the purpose of pollution sequestration.
- **Furfuryl Glycidyl Ether (FGE):** A specific chemical compound derived from agricultural waste that is used as one of the cleavable linkers for the degradation module.