

Multifunctional Hemp-Derived Nanosheet Reinforced Bio-Composites

Executive Summary

This proposal outlines a focused research program to evaluate hemp-derived carbon nanosheets as dual-function fillers in epoxy and bio-epoxy systems, targeting both electrical conductivity and mechanical reinforcement within a unified composite architecture.

Core Hypothesis

Hemp-derived carbon nanosheets can simultaneously enable low-threshold electrical percolation (<1 wt%) and measurable mechanical reinforcement through load transfer and crack deflection mechanisms.

Key Innovation

Unlike conventional fillers, hemp nanosheets act as high-aspect-ratio 2D reinforcements forming conductive networks while enhancing stiffness and fracture resistance.

Target Performance Metrics

- Percolation threshold: < 1 wt%
- Electrical conductivity: > 10^{-2} S/m
- Tensile modulus increase: +20–50%
- Strength retention: > 80% vs neat resin

Primary Application Target

Multifunctional structural materials for EMI shielding, lightweight electronics, and conductive panels.

Experimental Plan

Phase 1: Baseline epoxy vs bio-epoxy systems with nanosheet fillers.

Phase 2: Electrical percolation mapping (0.1–5 wt%).

Phase 3: Mechanical reinforcement characterization.

Phase 4: Hybrid systems (nanosheets + biochar + fibers).

Phase 5: Fully bio-based composite system.

Characterization

- Electrical conductivity (4-point probe)
- Mechanical testing (tensile, modulus, fracture toughness)
- Thermal analysis (TGA, DSC)
- Morphology (SEM fracture analysis for crack deflection and bridging)

Key Technical Risks

- Nanosheet dispersion and agglomeration
- Interfacial bonding limitations
- Reduced performance in fully bio-based curing systems

Strategic Positioning

This work positions hemp-derived nanosheets as a bio-based alternative to graphene-like reinforcements in multifunctional composite systems.

Collaboration Opportunity

Seeking collaboration to validate dual-function performance, access nanosheet materials, and co-develop high-impact research outcomes.