

AI Disclosure

- **Model:** Gemini
- **Verification State:** Based on the attached technical report *Hempoxies 99% Hemp.pdf* by Marie-Soleil Seshat Landry (August 2026). Live references verified via provided context.

Keywords

Hempoxies, Multiscale Vitrimer Composite, Epoxidized Hempseed Oil, Maleinized Hempseed Oil, Zinc Acetylacetonate, Dynamic Transesterification, Bio-Based Epoxy.

Commercialization & Empirical Testing Strategy: Hempoxies Platform

Executive Summary

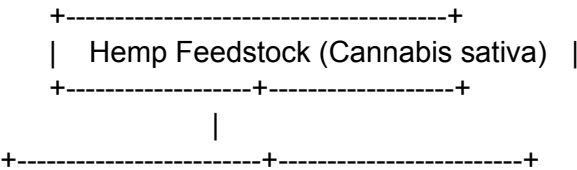
This business plan outlines a phased empirical testing and commercialization framework to validate and scale the **Hempoxies** platform—a >99% hemp-derived multiscale vitrimer composite utilizing dynamic β -hydroxy ester linkages. The plan targets initial market entry via high-margin replacement of petroleum thermosets and specialized structural applications by validating eight programmed material variants.

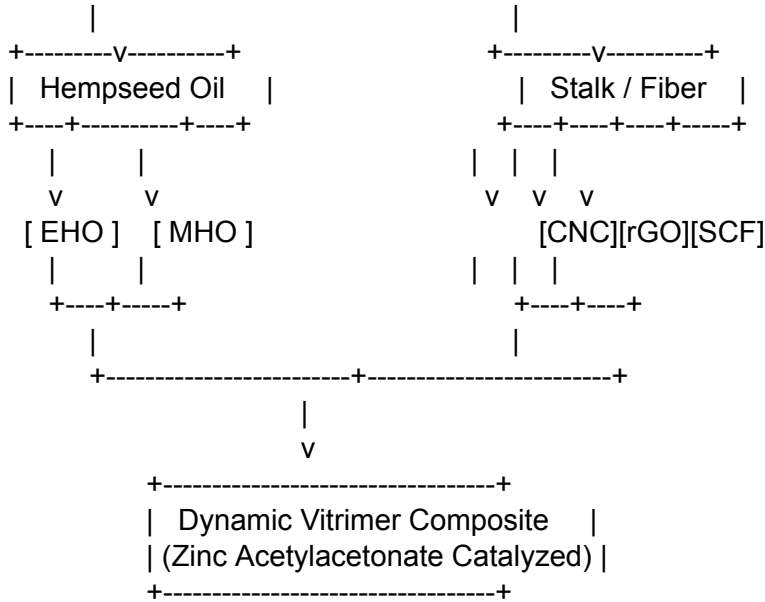
1. Scope & Objective

- **Core Objective:** Empirically validate the 8 programmed variant formulations (HEMP-AL, HEMP-STEEL, HEMP-PLAST, HEMP-CRETE, HEP-OXY, HEMP-KEV, HEMP-TITAN, HEMP-GFRP) to establish performance baselines against incumbent industrial materials.
- **Commercialization Target:** License formulation protocols (SOP-EHO-001 through SOP-CAT-001) and produce high-performance bio-vitrimer prepregs and resins for circular economy manufacturing.

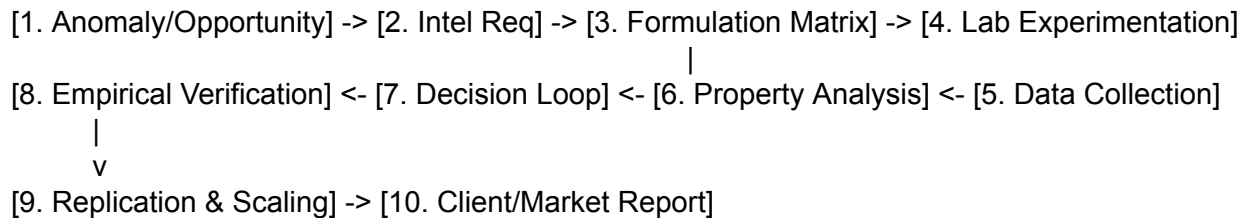
2. Context & Strategic Alignment

Conventional thermoset composites pose severe end-of-life disposal challenges, while standard thermoplastics lack high-temperature creep resistance. Hempoxies addresses both limitations by combining high specific mechanical properties with thermally activated transesterification exchange catalyzed by zinc acetylacetonate ($\text{Zn}(\text{acac})_2$, $\tau^{*} < 300\text{ s}$) at 180–200 °C).





3. Methodology & 10-Step Operational Plan



1. **Observe Anomaly:** Identify supply chain vulnerability and uncyclable waste streams in petroleum epoxy and thermoset composite markets.
2. **Define Intel Req:** Establish exact lab parameters required to validate mechanical, thermal, and dynamic reprocessing performance for each variant.
3. **Hypothesize / Design Matrix:** Batch-produce matrix components (EHO via SOP-EHO-001, MHO via SOP-MHO-001, FGE via SOP-FGE-001).
4. **Design Experiment:** Standardize mixing protocols using the prescribed ethanol dispersion medium (SOP-ETOH-001) and three-roll milling / planetary mixing.
5. **Collect Data:** Record mechanical, thermal, and rheological metrics under ASTM/ISO standards across all 8 variants.
6. **Analyze Data:** Assess stress relaxation times (τ^*) and specific modulus/strength ratios against target incumbents.
7. **Decision Loop:** Reject or adjust batches where filler loading suppresses transesterification ($\tau^* > 300\text{ s}$) or where catalyst adsorption occurs on GO surfaces ($\text{Zn}(\text{acac})_2$).
8. **Conclusion:** Certify bio-based carbon content (>99% ASTM D6866) and specific property advantages.
9. **Replicate:** Scale synthesis from lab-scale (1–5 kg) to pilot batching (50–100 kg).
10. **Report:** Deliver certified technical datasheets (TDS) and white papers to commercial

off-takers.

4. Empirical Testing Framework (Target Variants vs. Incumbents)

Variant ID	Incumbent Target	Core Formulation Adjustment	Target Testing Standard	Key Target Performance
HEMP-AL	Aluminum 6061-T6	Anhydride-rich (45:55), 25 phr short carbon fiber (aligned)	ASTM D3039, ASTM D7028	Specific Modulus: $28.1 \frac{\text{GPa}}{\text{cm}^3}$ (+9.8%)
HEMP-STEEL	Mild Steel	22 phr carbon fiber (random-in-plane), 4 phr biochar	ASTM D3039, ASTM D6110	Specific Strength: $167 \frac{\text{MPa}}{\text{cm}^3}$ (+193%)
HEMP-PLAST	ABS Plastic	Epoxide-rich (55:45), 12 phr FGE, 8 phr biochar	ASTM D638, ASTM D256	Tensile Strength: 85 MPa (+113%), Ductile
HEMP-CRETE	C30 Concrete	15 phr biochar + 30 phr coarse biochar aggregate	ASTM C39, ASTM C496	Compressive: 55 MPa, Tensile: 35 MPa
HEP-OXY	Petroleum DGEBA	Stoichiometric 49:49, 15 phr short fiber, 2 phr catalyst	ASTM D3039, ASTM D5868	Tensile Strength: 140 MPa (+100%), Welded
HEMP-KEV	Kevlar-49	Anhydride-rich (40:60), 30 phr aligned short fiber	ASTM D3039, ASTM D7136	Fiber $V_f \approx 0.35$, Impact Toughness
HEMP-TITAN	Ti-6Al-4V	28 phr aligned fiber, 3.6 phr hybrid nano-tier	ASTM D3039, ASTM E831	Specific Modulus: $30.4 \frac{\text{GPa}}{\text{cm}^3}$ (+18%)
HEMP-GFRP	E-Glass/Epoxy	20 phr short fiber, 4 phr biochar, 1.5 phr CNC	ASTM D3039, ASTM D2344	Mass Reduction: -28%, 100% Reprocessable

5. Commercialization Roadmap & Milestones

Phase 1: Lab-Scale Synthesis & Protocol Certification (Months 1–6)

- Execute SOP-EHO-001 through SOP-CAT-001 to produce 5 kg pilot quantities of base resin and nanofillers.
- Conduct ASTM testing for HEP-OXY, HEMP-PLAST, and HEMP-AL variants.
- Validate vitrimer stress relaxation ($\tau^* < 300 \text{ s}$) at 180 °C via DMA) and verify dynamic network retention after 3 grind-remold cycles.

Phase 2: Pilot Production & Material Characterization (Months 7–12)

- Establish continuous three-roll milling and planetary mixing facilities for 50 kg/month capacity.
- Validate remaining structural variants (HEMP-STEEL, HEMP-CRETE, HEMP-KEV, HEMP-TITAN, HEMP-GFRP).
- Submit samples for third-party ASTM D6866 / ISO 16620 radiocarbon verification to confirm >99% bio-based content.

Phase 3: B2B Off-Take Partnerships & Licensing (Months 13–24)

- Target high-margin initial adoption sectors:
 1. **Automotive / Consumer Goods:** Replace petroleum ABS with HEMP-PLAST.
 2. **Industrial Epoxy Coatings / Composites:** Replace DGEBA resin with HEP-OXY.
 3. **Circular Clean Tech:** Deploy HEMP-GFRP for recyclable wind turbine blade subcomponents.
- Secure strategic licensing agreements with regional bio-mass processors and composite manufacturers.

6. Risk Management & Technical Countermeasures

- **Catalyst Starvation / Adsorption:** Nanofillers (HGO/HrGO) adsorb $\text{Zn}(\text{acac})_2$, hindering dynamic exchange.
 - *Mitigation:* Apply a +0.5 phr to 1.0 phr catalyst compensation for total nanofiller loadings >2.0 phr or pre-treat HGO with catalyst solution prior to resin mixing.
- **High Processing Viscosity:** High fiber/nanofiller content restricts resin flow during molding.
 - *Mitigation:* Utilize 8–12 phr FGE as a reactive diluent to suppress uncured resin viscosity to 2000–3000 mPa·s at 80 °C.
- **Anhydride/Epoxy Imbalance:** Deviations from stoichiometry alter network rigidity or reduce reprocessability.
 - *Mitigation:* Maintain strict titration controls (oxirane oxygen target 7.0–7.5%; acid number target 100–110 mg KOH/g) prior to matrix blending.

7. Conclusions & Strategic Directives

The Hempoxies technology provides a clear business path to disrupt petroleum-derived thermosets. By leveraging a single monoculture crop (*Cannabis sativa L.*) for matrix, cross-linker, diluent, and multiscale reinforcement, Landry Industries can offer high-value structural materials that combine the mechanical performance of thermosets with the circular reprocessability of thermoplastics.

Follow-up Directive: Which specific variant (e.g., **HEP-OXY** for direct epoxy replacement or **HEMP-AL** for structural automotive parts) would you like to prioritize for initial lab-scale prototyping and financial model forecasting?