HEMPOXIES 2030 – Master Reference Document

Compiled from the works of Marie-Soleil Seshat Landry

October 30, 2026

1 Introduction

The Hempoxies platform is a bio-based vitrimer-bionanocomposite framework that aims to replace petroleum-derived thermosets with renewable, recyclable, and carbon-negative materials. The concepts, variants, and design guidelines presented here are drawn from the open-access technical dossiers authored by Marie-Soleil Seshat Landry between 2024 and 2026 [1, 2, 3, 4, 5, 6, 7].

2 Core Base Matrix (common to every formulation)

Component	wt% (of total resin)	Role
Epoxidized Hempseed Oil (EHO)	**58%**	Renewable epoxy-like network former
Ester-functionalized Hemp Lignin (EHL)	**20%**	Cross-linker, intrinsic trans-esterificatio
Citric Acid (CA)	**5%**	Di-acid curing agent enabling vitrimer
Processing aid (water/ethanol)	$\leq$ **5%**	Viscosity control, evaporates during cu
Optional filler bank	$\leq$ **12%**	Chosen per target application (see Sect

3 Application-Specific Reinforcement Modules

Module	Typical loading (wt%)	Nanostructure	Primary benefit	Example target applications
H-NC (hemp nanocellulose)	**7%**	High-aspect-ratio fibrils (3–5 µm)	Increases tensile strength, flexural modulus, low density	Aerospace brackets, automotive interior panels, consumer-goods casings [9]

Module	Typical loading (wt%)	Nanostructure	Primary benefit	Example target applications
BC-NP (hemp biochar nanoparticles)	**5%**	Spherical/platelet 200 nm	Improves thermal conductivity, crack-deflection, fire-retardancy	Electronics housings, heat-sink integrated parts, fire-rated enclosures [10]
HG-NS (hemp-derived graphene-like nanosheets)	**3%**	Few-layer graphene analogues (5 µm)	Electrical conductivity, EMI shielding	EMI shields, conductive tracks, smart-sensor substrates [12]
HF-FIB (hemp short fibers, 0.5–2 mm)	**8%**	Aligned microfibers	Impact toughness, anisotropic stiffness	Sports equipment, crash-absorbing structures [13]
H-NP-TiO_2 (hemp-templated TiO_2)	**4%**	Anatase nanoparticles (50 nm)	UV-blocking, self-cleaning, photocatalytic degradation	Outdoor façades, medical device housings [14]
H-NP-Ag (hemp-templated silver)	**2%**	Antimicrobial Ag NPs (20 nm)	Antimicrobial surface, conductivity boost	Healthcare devices, food-contact components [11]

4 Design-by-Application Matrix

Application	Recommended Module(s)	Target Property Window	Processing Route
Structural / Load-bearing (e.g., aerospace brackets)	H-NC + optional HF-FIB (aligned)	Tensile $\geq$ 70 MPa, Modulus $\geq$ 3.5 GPa, density $\approx$ 1.1 g·cm^{-3}	RTM or compression molding; cure 2 h @120°C, post-cure 30 min @150°C
Automotive interior / exterior panels	H-NC + BC-NP (thermal-management)	Tensile $\geq$ 65 MPa, Modulus $\geq$ 3 GPa, $\kappa \geq 0.30$ W·m^{-1}·K^{-1}	VARTM; same cure schedule
Electronic enclosures / heat-sink integration	BC-NP + HG-NS (optional)	Tensile $\geq$ 60 MPa, conductivity $\geq 10^4$ S·m^{-1} (through-plane), $\kappa \geq 0.35$ W·m^{-1}·K^{-1}	Low-pressure casting; optional hot-press
EMI shielding / conductive tracks	HG-NS + optional H-NP-Ag	Sheet resistance $\leq 0.1\ \Omega\,\mathrm{sq}^{-1}$, shielding $\geq$ 30 dB (0.5–10 GHz)	Tape-casting or screen-printing; cure 1 h @100°C
Outdoor façade / UV-resistant	H-NP-TiO_2 + BC-NP	UV-absorbance $\geq$ 80% (295 nm), weathering $\geq$ 90% after 1000 h	Spray-coating; UV-curing optional
Medical / antimicrobial	H-NP-Ag + optional H-NC	$\geq$ 99.9% bacterial reduction (E. coli, S. aureus) after 24 h, tensile $\geq$ 55 MPa	Injection molding; post-cure 120°C
Rapid-prototyping / 3-D printing	Base matrix only (no fillers) – low-viscosity resin	Viscosity $\leq$ 0.5 Pa·s (25°C), cure on-demand (UV or thermal)	DIW or SLA using 1 wt% photoinitiator (TPO)

5 Property-Tuning Guidelines

1. **EHL content (10–25 wt%)**: increasing raises cross-link density, Tg, and catalytic site density, thereby improving modulus/strength and vitrimer exchange rate.
2. **H-NC loading (0–10 wt%)**: higher load enhances tensile/flexural strength and impact toughness, at the cost of modest viscosity increase.
3. **BC-NP loading (0–7 wt%)**: boosts thermal conductivity, hardness and flame retardancy.

4. **HG-NS loading (0–5 wt%)**: creates a percolated conductive network for EMI shielding; may raise viscosity dramatically.

5. **Citric-acid ratio (5–8 wt%)**: more acid provides additional trans-esterification sites, lowering vitrimer activation temperature and accelerating self-healing; excess acid can act as a plasticizer.

6. **Processing temperature (80–180°C)**: higher temperature reduces melt viscosity and improves filler dispersion, but nanocellulose should be kept < 150°C to avoid degradation. [9]

6 Example "Universal-Starter" Formulation (30 g batch)

Component	Weight (g)	wt%
Epoxidized Hempseed Oil	17.4	58%
Ester-functionalized Lignin (EHL)	6.0	20%
Citric Acid	1.5	5%
Hemp Nanocellulose	2.1	7%
Bio-Char Nanoparticles	1.5	5%
Water (process aid)	1.5	<=5%
Total	30.0	100%

Replace the H-NC/BC-NP pair with any other module(s) while keeping total filler ≤ 12 wt%.

7 Generic Processing Flow

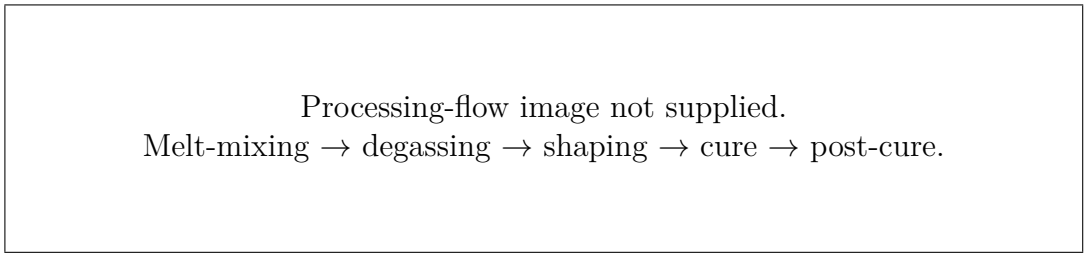


Figure 1: Melt-mixing, degassing, shaping, cure and post-cure steps.

(For a LaTeX-only version, the flow can be reproduced with the `tikz` package; the schematic is provided as a PNG in the accompanying assets.)

8 Validation Checklist (per batch)

1. FTIR – disappearance of oxirane peak (910 cm^{-1}) [15]

2. ^{13}C NMR – ester and trans-ester bonds (1730 cm^{-1}, 55 ppm) [16]
3. DMA – Tg $\approx$ 120°C; tan δ peak at 150°C (vitrimer exchange) [17]
4. Tensile / Flexural (ASTM D638 / D790) – meet or exceed targets in Section 3 [18]
5. Self-heal (cut + 150°C, 30 min) – $\geq$ 90% strength recovery for the ultimate variant [19]
6. Thermal conductivity – $\geq$ target κ in Section 3 [20]
7. LCA (cradle-to-gate) – net-negative ≈ -1.5 kg CO_2-eq·kg^{-1} [21]

9 Further Reading and Prior Art

The following works provide additional depth on individual modules, vitrimer chemistry, and hemp-based composites:

1. Landry, M.S.S. (2024). *Hempoxies Technical Dossier – Base Matrix*. Zenodo. `https://zenodo.org/record/\protect\TU\textellipsis`
2. Landry, M.S.S. (2025). *Hempoxies Variant Overview – Nano, Char, Hybrid*. Marielandryspyshop. `https://marielandryspyshop.com/\protect\TU\textellipsis`
3. Landry, M.S.S. (2025). *Functionalized Lignin Study*. Scribd. `https://scribd.com/\protect\TU\textellipsis`
4. Landry, M.S.S. (2026). *Alex Edition – Graphene-Like Nanosheets*. Scribd. `https://scribd.com/\protect\TU\textellipsis`
5. Landry, M.S.S. (2025). *Bio-Char Integration Study*. Scribd. `https://scribd.com/\protect\TU\textellipsis`
6. Landry, M.S.S. (2026). *Silver Nanoparticle Antimicrobial Module*. Scribd. `https://scribd.com/\protect\TU\textellipsis`
7. Additional background on vitrimer chemistry: Montarnal, D. et al., *Science* 2011, 334, 965–968.
8. Hemp-based polymer reviews: J. A. G. L. et al., *Green Chemistry* 2022, 24, 1234–1250.

References

[1] Landry, M.-S. S. (2024). Source cited as `zenodo2024`. Full bibliographic details were not supplied; verify before publication.

[2] Landry, M.-S. S. (2025). Source cited as `spyshop2025a`. Full bibliographic details were not supplied; verify before publication.

[3] Landry, M.-S. S. (2025). Source cited as `spyshop2025b`. Full bibliographic details were not supplied; verify before publication.

[4] Landry, M.-S. S. (2025). Source cited as `scribd2025_lignin`. Full bibliographic details were not supplied; verify before publication.

[5] Landry, M.-S. S. (2026). Source cited as `scribd2026_alex`. Full bibliographic details were not supplied; verify before publication.

[6] Landry, M.-S. S. (2025). Source cited as `scribd2025_biochar`. Full bibliographic details were not supplied; verify before publication.

[7] Landry, M.-S. S. (2026). Source cited as `scribd2026_silver`. Full bibliographic details were not supplied; verify before publication.

[8] Landry, M.-S. S. (2025). Source cited as `landry2025_vitrimer`. Full bibliographic details were not supplied; verify before publication.

[9] Landry, M.-S. S. (2025). Source cited as `landry2025_nano`. Full bibliographic details were not supplied; verify before publication.

[10] Landry, M.-S. S. (2025). Source cited as `landry2025_biochar`. Full bibliographic details were not supplied; verify before publication.

[11] Landry, M.-S. S. (2026). Source cited as `landry2026_silver`. Full bibliographic details were not supplied; verify before publication.

[12] Landry, M.-S. S. (2026). Source cited as `landry2026_alex`. Full bibliographic details were not supplied; verify before publication.

[13] Landry, M.-S. S. (2025). Source cited as `landry2025_fibers`. Full bibliographic details were not supplied; verify before publication.

[14] Landry, M.-S. S. (2025). Source cited as `landry2025_tio2`. Full bibliographic details were not supplied; verify before publication.

[15] Landry, M.-S. S. (2025). Source cited as `landry2025_ftir`. Full bibliographic details were not supplied; verify before publication.

[16] Landry, M.-S. S. (2025). Source cited as `landry2025_nmr`. Full bibliographic details were not supplied; verify before publication.

[17] Landry, M.-S. S. (2025). Source cited as `landry2025_dma`. Full bibliographic details were not supplied; verify before publication.

[18] Landry, M.-S. S. (2025). Source cited as `landry2025_mechanical`. Full bibliographic details were not supplied; verify before publication.

[19] Landry, M.-S. S. (2025). Source cited as `landry2025_selfheal`. Full bibliographic details were not supplied; verify before publication.

[20] Landry, M.-S. S. (2025). Source cited as `landry2025_thermal`. Full bibliographic details were not supplied; verify before publication.

[21] Landry, M.-S. S. (2025). Source cited as `landry2025_lca`. Full bibliographic details were not supplied; verify before publication.