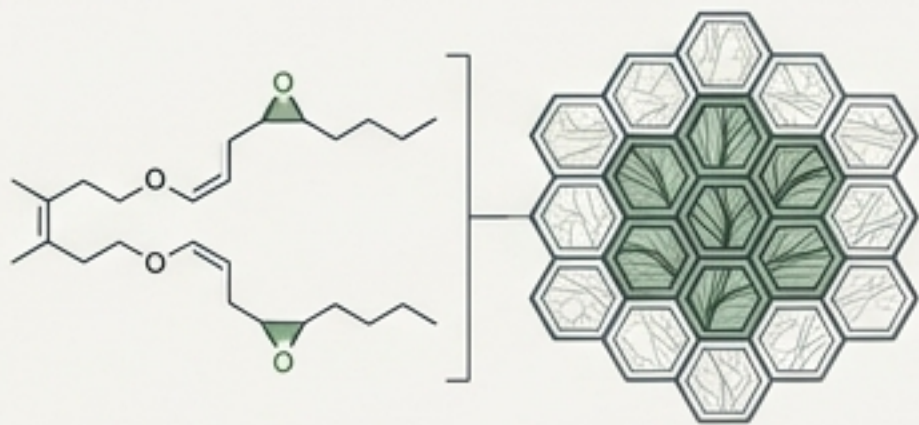


Hempoxies 54: The Programmable Vitrimer Composite Platform

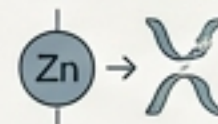
Architecture



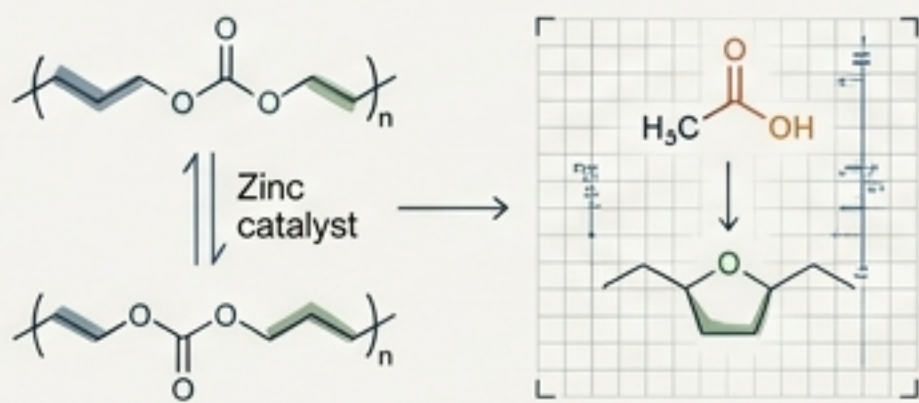
Epoxidized Hempseed Oil (EHO) Vitrimer
Matrix + Hierarchical Bio-Carbon



Mechanism



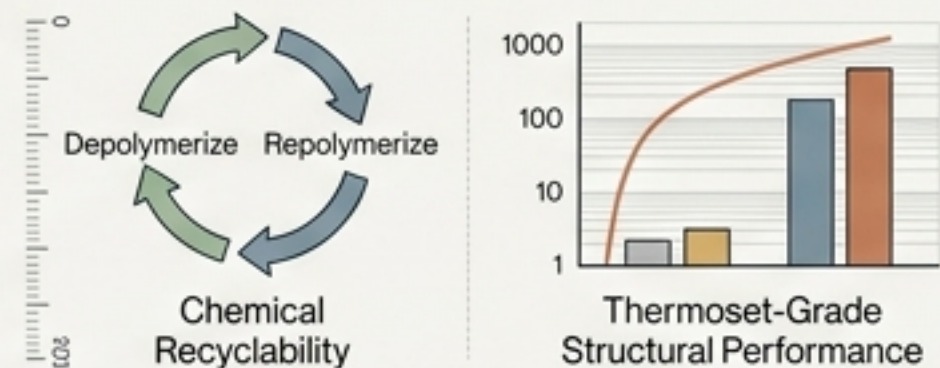
Zinc-Catalyzed Transesterification &
Acetic-Acid Ring Opening



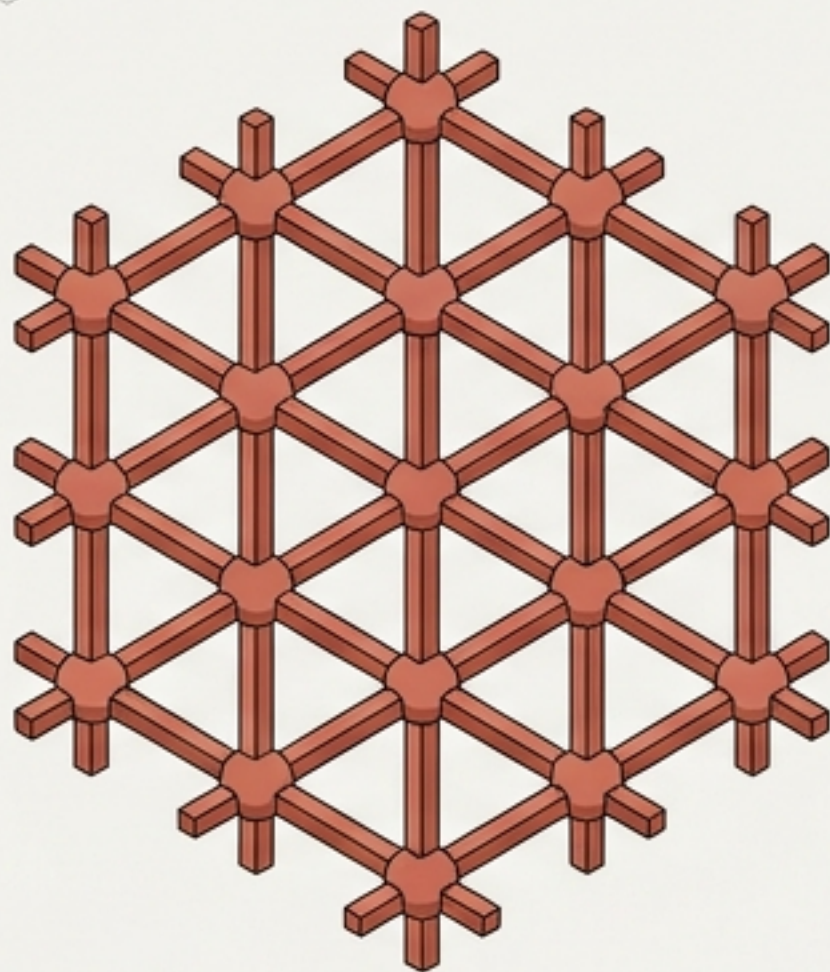
Capability



Covalent Adaptable Network (CAN) enabling
full chemical recyclability with thermoset-
grade structural performance.

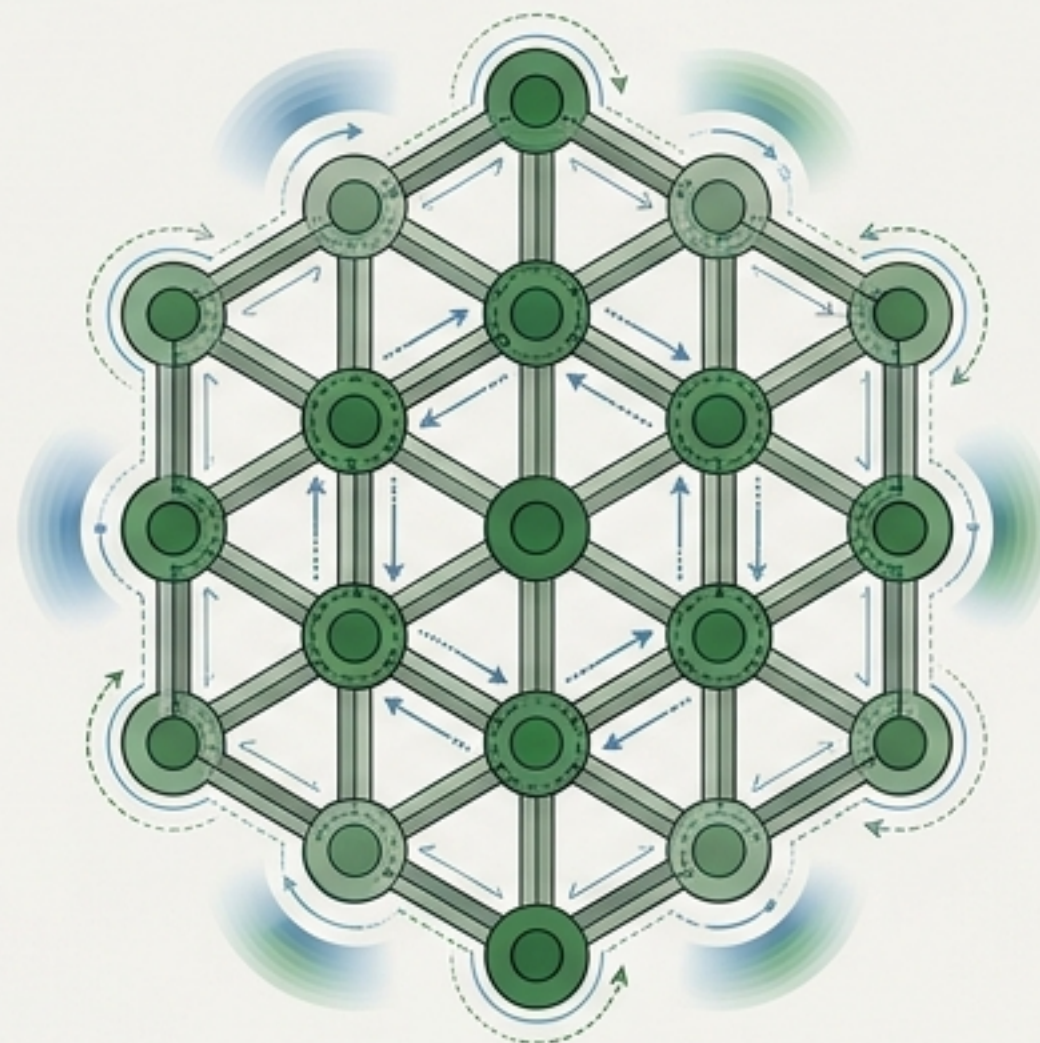


Traditional Thermosets



Excellent high-performance load bearing, but ends in a dead-end lifecycle (landfill or incineration).

The Vitrimer Solution (CANs)



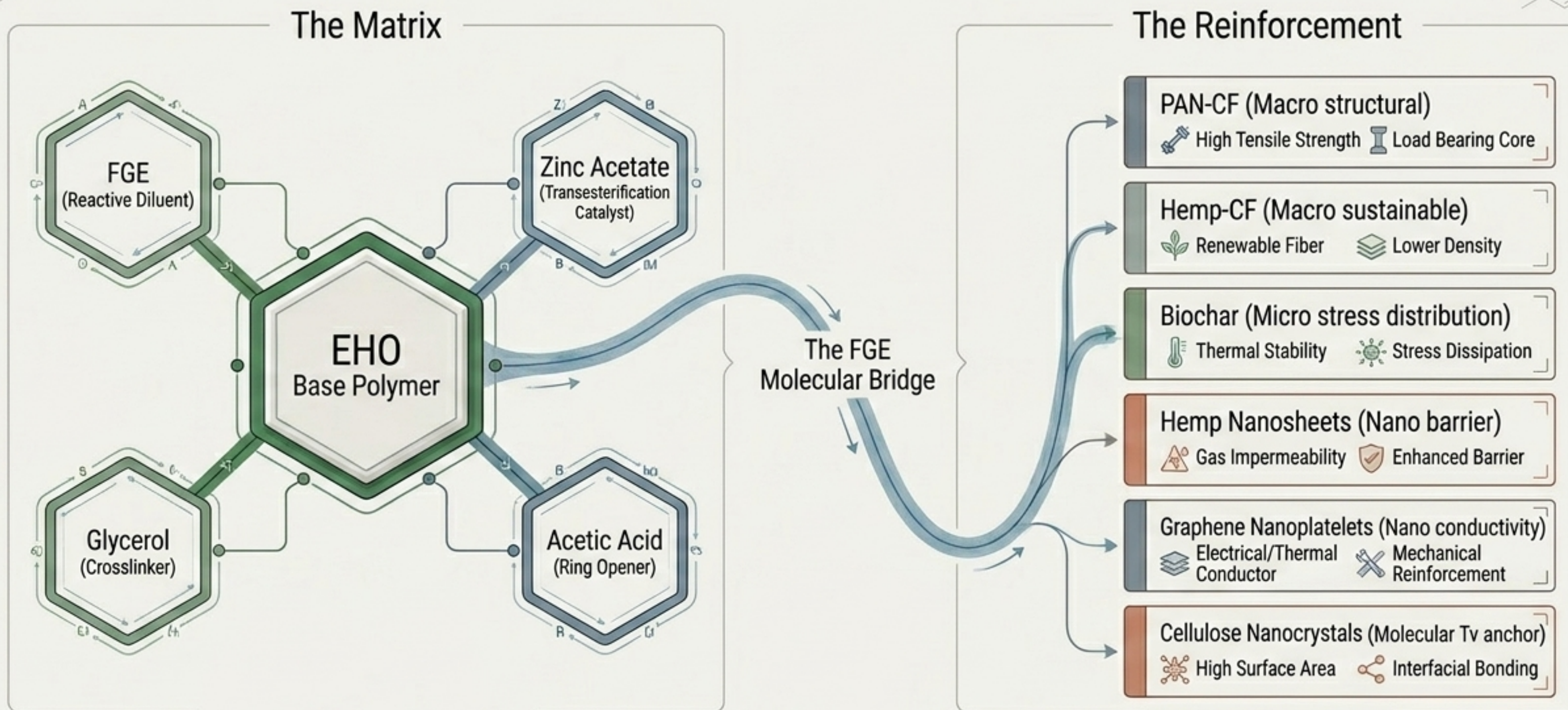
Vitrimers introduce associative exchange reactions. They preserve crosslink density and structural integrity while enabling topology rearrangement under thermal activation. High performance meets circularity.

Thermoplastics



Fully circular and melt-processable, but suffers from lower structural integrity and creep under load.

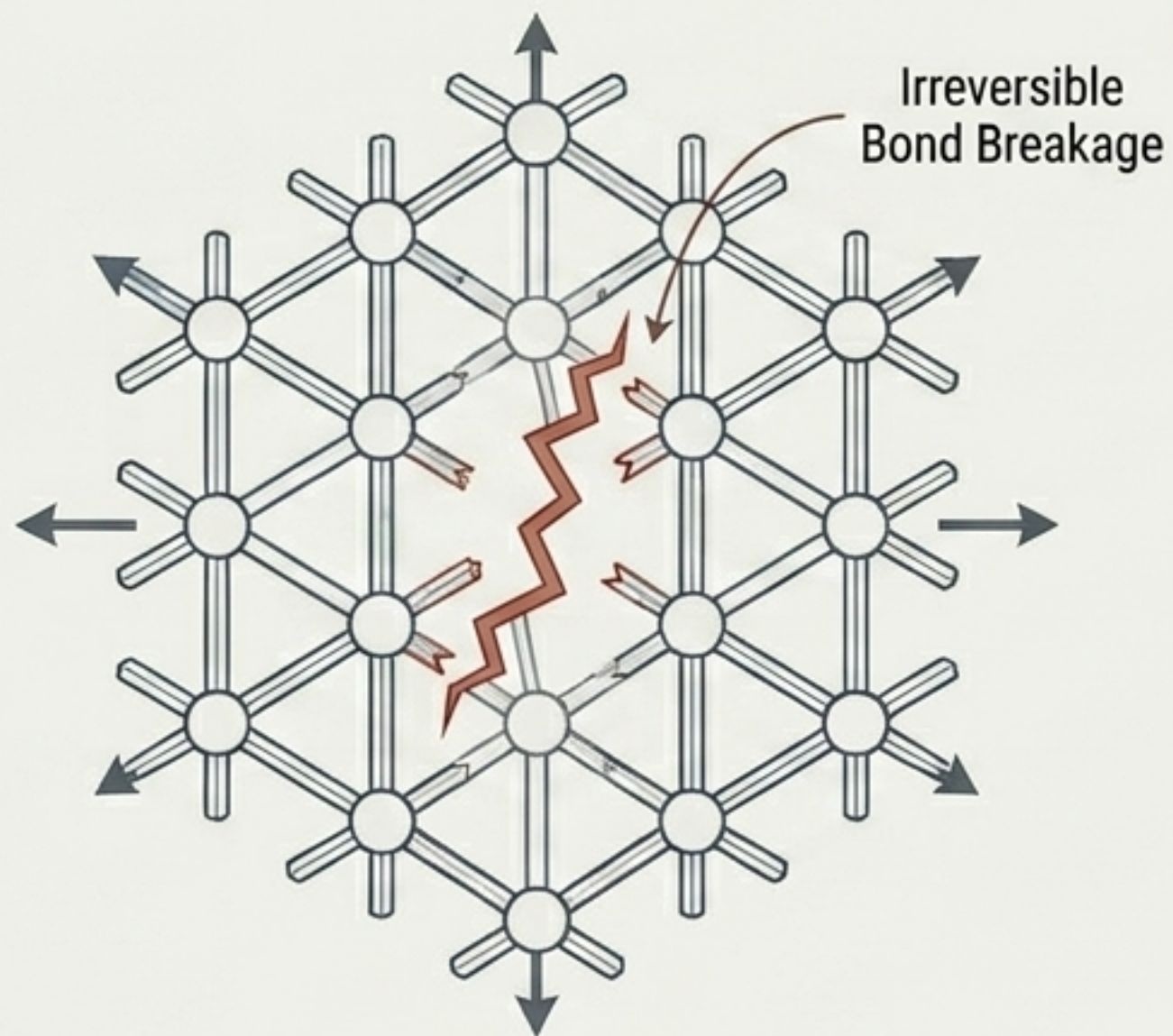
HEMPOXIES 54: EHO VITRIMER COMPOSITE SYSTEM ARCHITECTURE



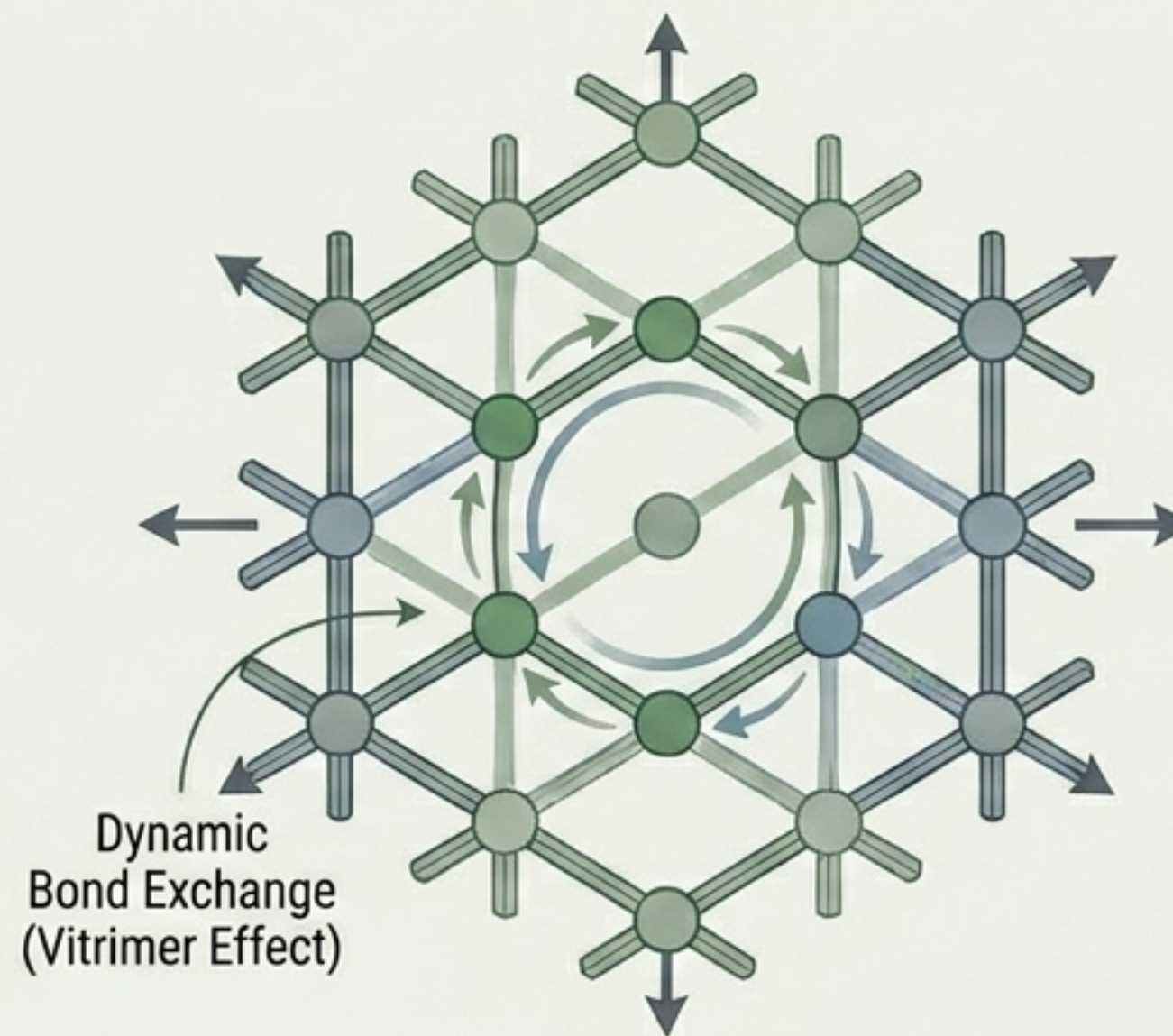
HEMPOXIES 54: EHO VITRIMER COMPOSITE SYSTEM ARCHITECTURE

The Vitrimer Mechanism: Matrix Behavior Under Stress

Static Thermoset



Hempoxies 54 Dynamic Network

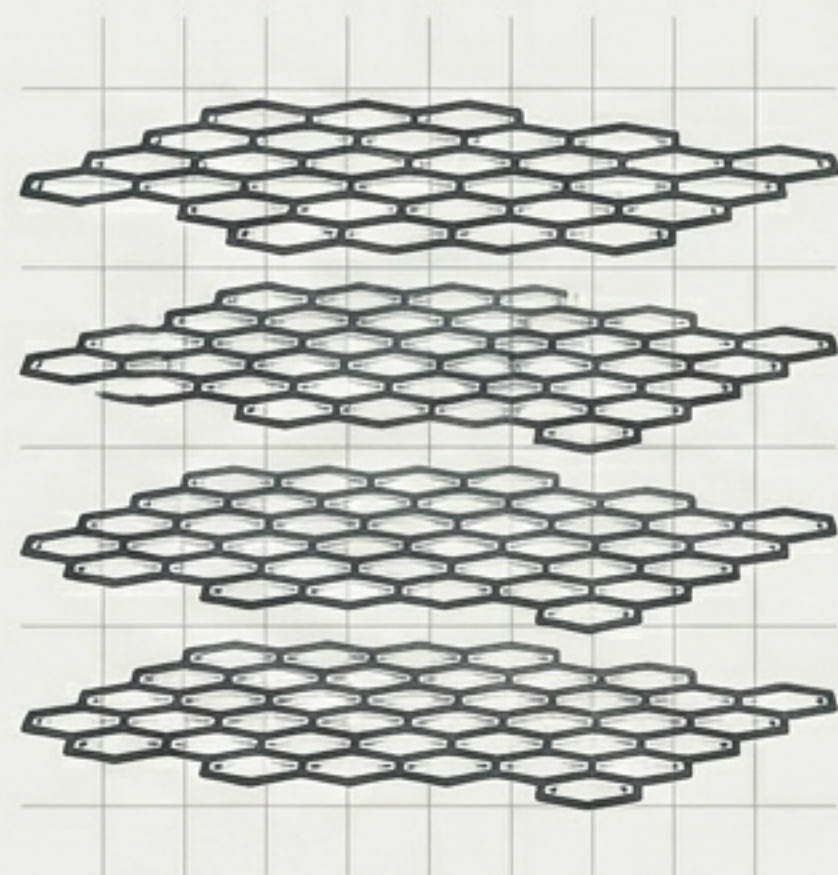


Base
Polyunsaturated hempseed oil
(OOC 4-7%).

Activator
Acetic acid generates the critical
beta-hydroxy esters via epoxy ring-opening.

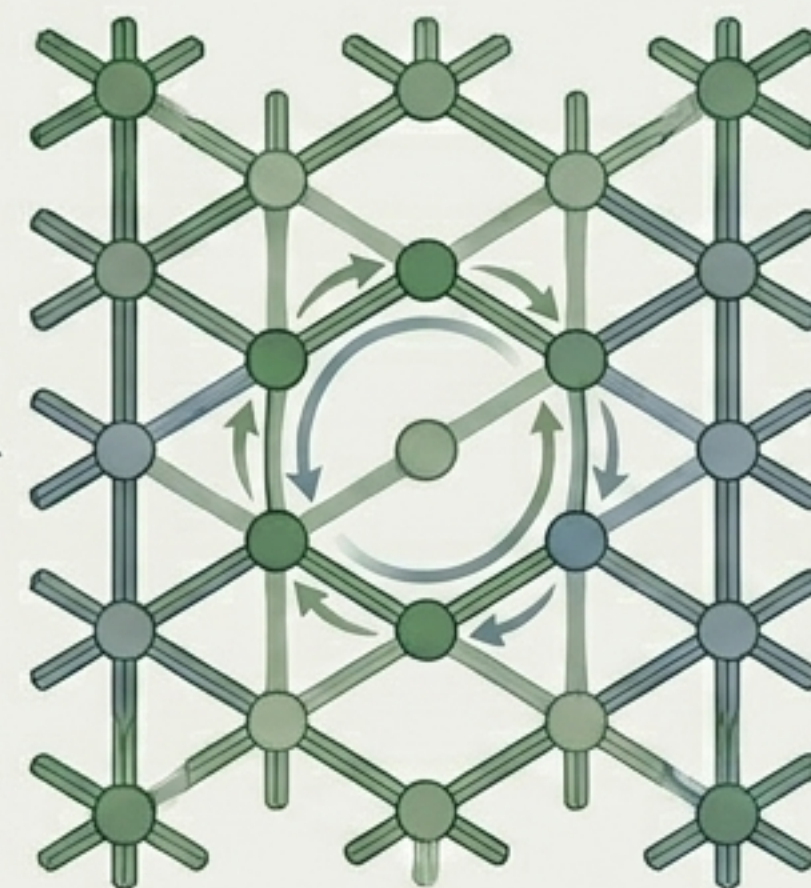
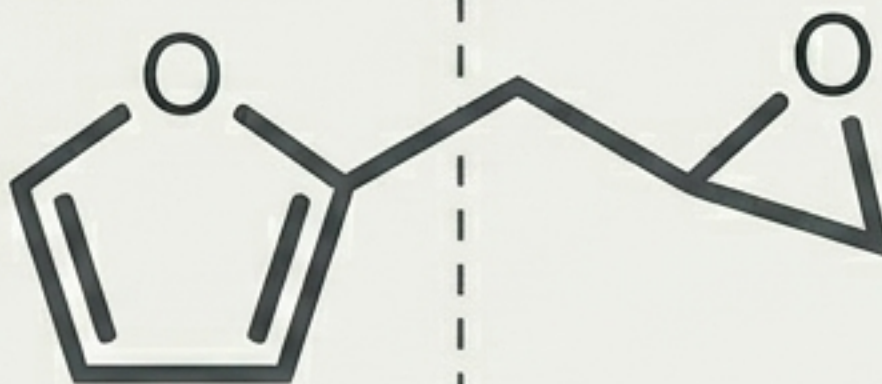
Exchange
Zn²⁺ coordination enables bond
shuffling without depolymerization.

The Aha Mechanism: Furfuryl Glycidyl Ether (FGE)



Non-Covalent pi-pi Anchor

Stacks on carbon surfaces (Delta G approx -0.3 to -0.5 eV per ring), bypassing the need for heavy matrix surface oxidation.



Covalent Vitrimer Node

Reacts fully into the network via ring-opening, acting as a reactive diluent (drops viscosity from 60 to 15 mPa-s) without plasticizing the composite.

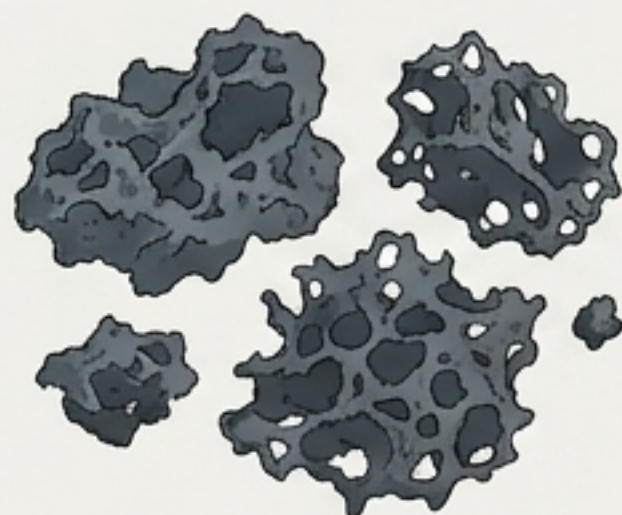
Hierarchical Carbon Architecture



Macro Scale (>1 mm)

PAN-CF & Hemp-CF

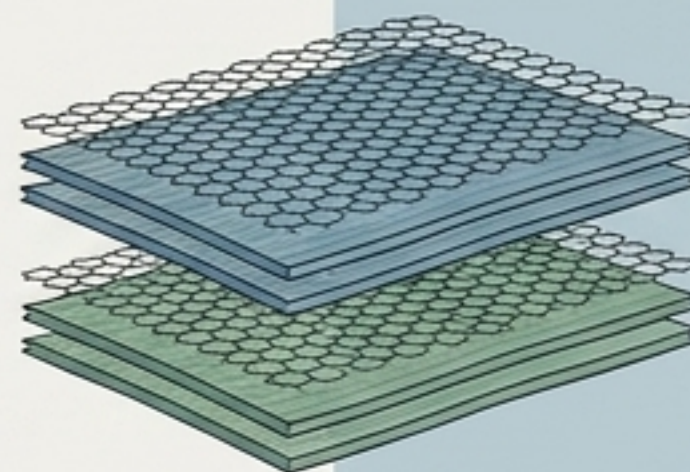
Role: Primary load bearing,
modulus 200+ GPa



Micro Scale (1-100 μm)

Hemp Biochar

Role: Isotropic stress distribution



Nano Scale (1-100 nm)

Graphene (GNP) &
Hemp Nanosheets

Role: Thermal/electrical
conductivity >2000 W/mK



Molecular Scale (<10 nm)

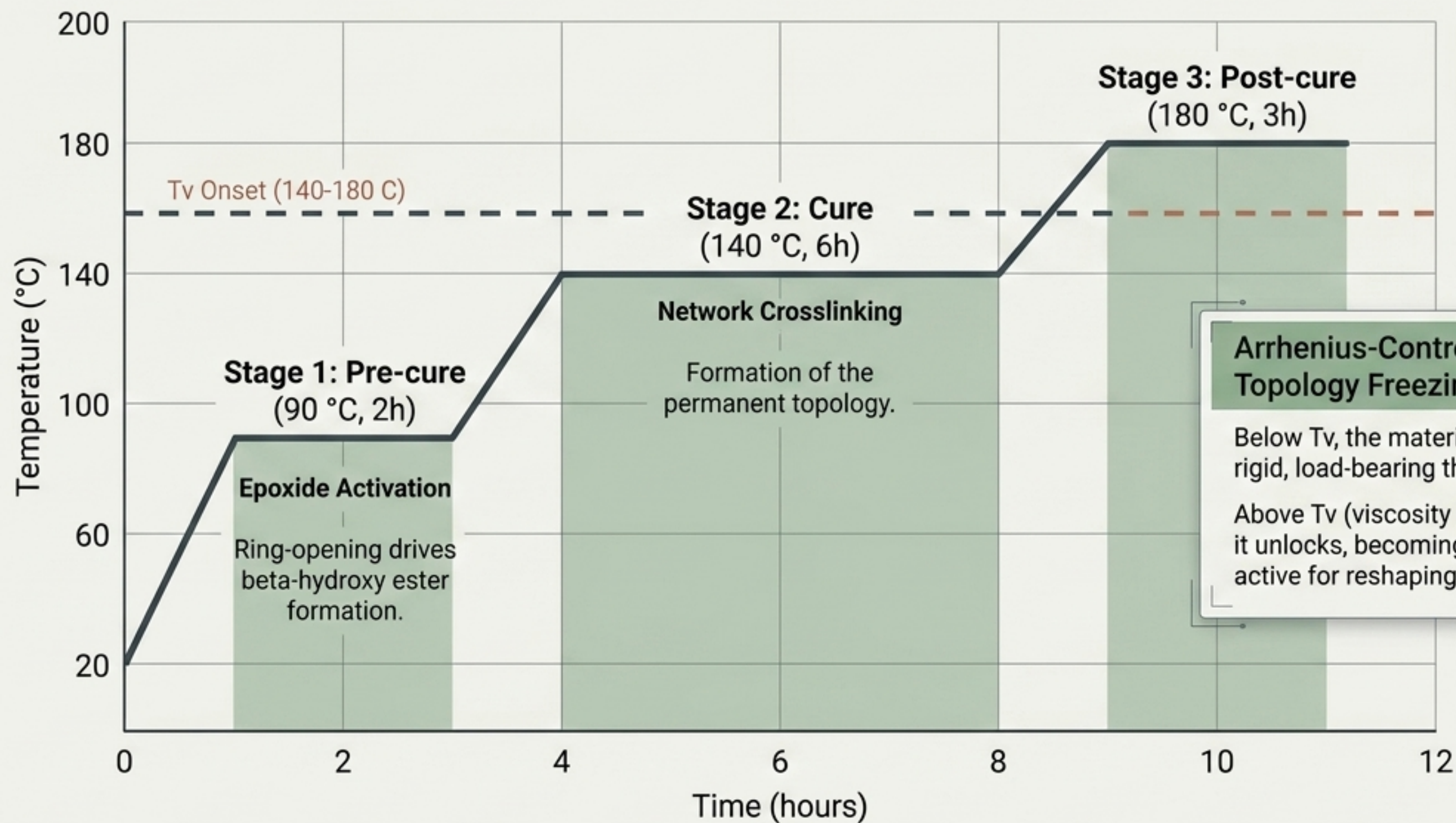
Cellulose Nanocrystals (CNC)

Role: Interfacial bonding and
molecular stiffness

The FGE pi-pi Interfacial Coupling Zone



Processing & Thermodynamics: Cure Schedule



The Programmability Matrix

	Tensile Strength	Stiffness/Modulus	Toughness	Thermal Stability	Conductivity	Barrier Properties	Tv Control	Reproce- sability
PAN-CF	Primary	Primary	None	None	None	None	None	None
Hemp-CF	High	High	High	Moderate	None	None	None	None
Biochar	None	None	Moderate	Moderate	None	None	None	None
Hemp Nanosheets (H-NS)	None	None	Moderate	Moderate	High	High	None	None
Graphene (GNP)	None	None	None	Primary	Primary	High	None	None
Hemp Nanocrystals (CNC)	None	None	Moderate	Moderate	None	None	Primary	Primary

Structural Anchor:

PAN-CF dominates pure tensile performance.

The Conductivity Engine:

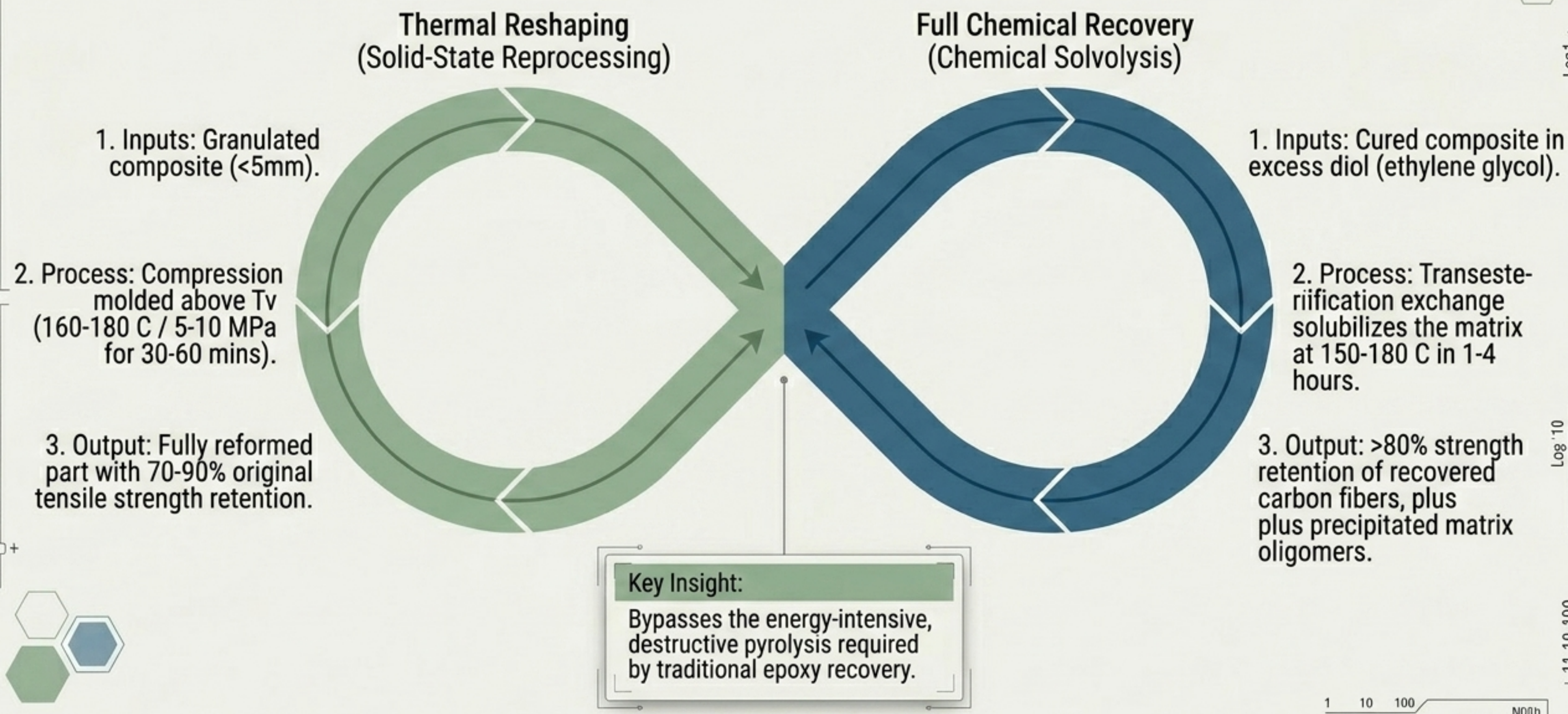
Graphene (GNP) serves as the primary driver for thermal and electrical pathways.

The Reprocessability Lever:

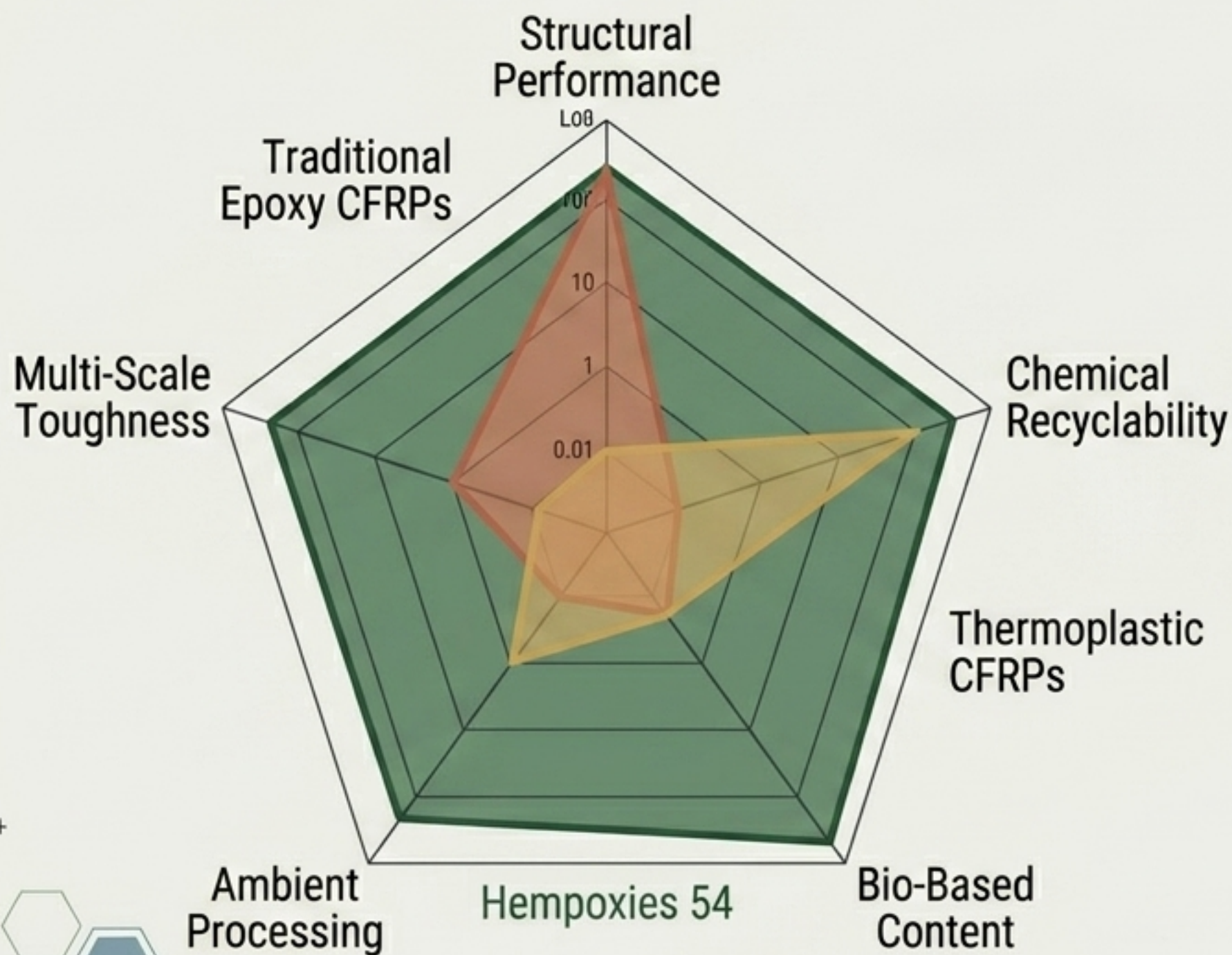
CNC is the sole reinforcement phase anchoring the Tv and driving recyclability via surface hydroxyls.

1 10 100 1000h

The Circular Lifecycle



Strategic Positioning: The Circular Convergence



The Circular Convergence.

Hempoxies 54 is not just a bio-resin; it is a fully integrated, multi-scale architecture. By bridging high-performance PAN carbon fibers with **bio-carbon** morphologies through a dynamic, Zn^{2+} catalyzed matrix, it unlocks the next generation of resilient, **reprogrammable infrastructure**.