

INTRODUCING VITRIMER COMPOSITES:

Unlocking the **circular economy** for composite materials



MALLINDA

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Vitrimers – New Polymer Class

Legacy Technologies

Thermoset



- Network Polymer
- Must be cured
- Permanent Shape
- Doesn't Melt

Thermoplastic



- Linear Polymer
- Remoldable
- Melts



- Reversible Chemistry
- Network Polymer
- Remoldable after cure
- Has Vitrimer Transition

VITRIMERS ARE:

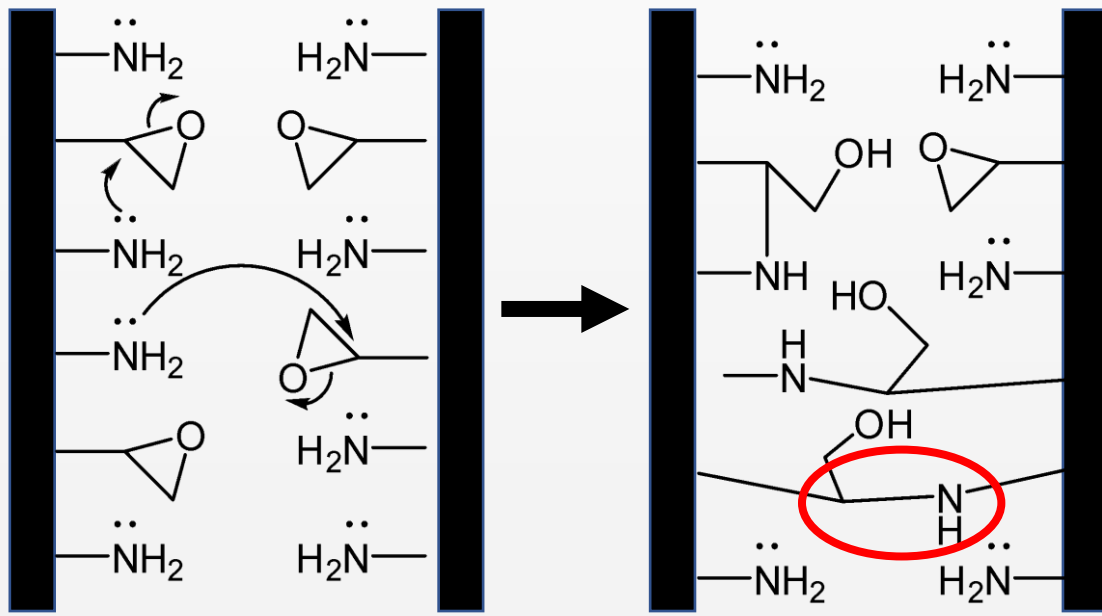
- A new class of resin, only recently discovered in academic polymer science.
- 100% Recyclable after cure/end of life.
- Covalent network polymers with high degree of crosslinking (similar in this way to thermosets).
- Reprocessable after cure when heated above the vitrimer transition temperature, due to exchange of chemical crosslinks
- Capable of diverse mechanical properties from elastomers to high modulus resins
- Applicable to moderately high temperature applications (up to 180C).

VITRIMERS ARE NOT:

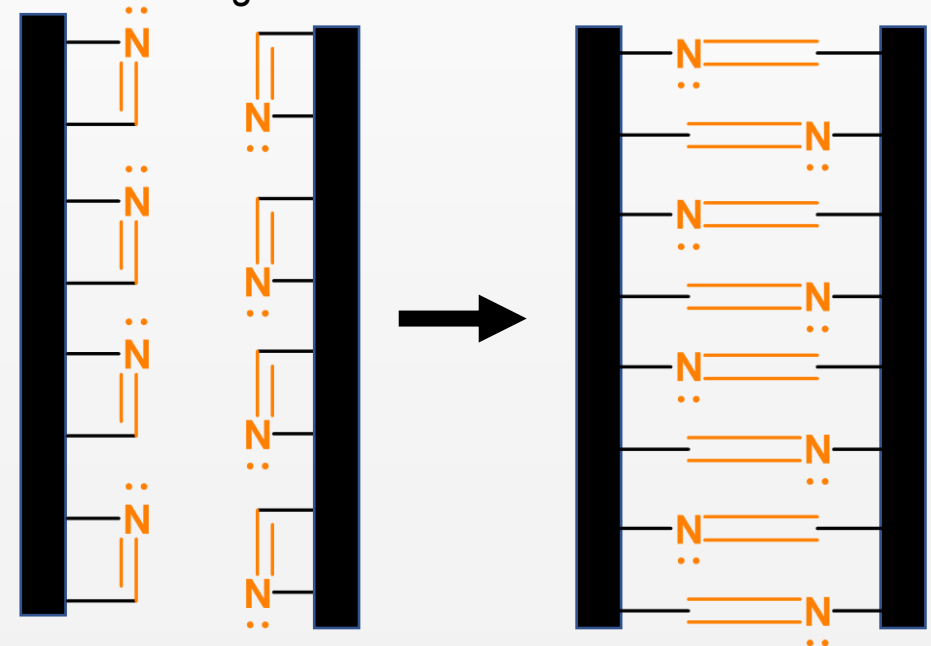
- Thermoplastics, since vitrimers are crosslinked.
- Thermosets, since vitrimers are reprocessable after cure.

Traditional Epoxy Resins

Bonding between layers gives thermoset strength.



Mallinda's technology has **exchangeable bonds** that allows bonding across the interface, even after curing.



Thermoset Composites



Low Density
Doesn't Creep
Fast Mfg Cycles
Recyclable



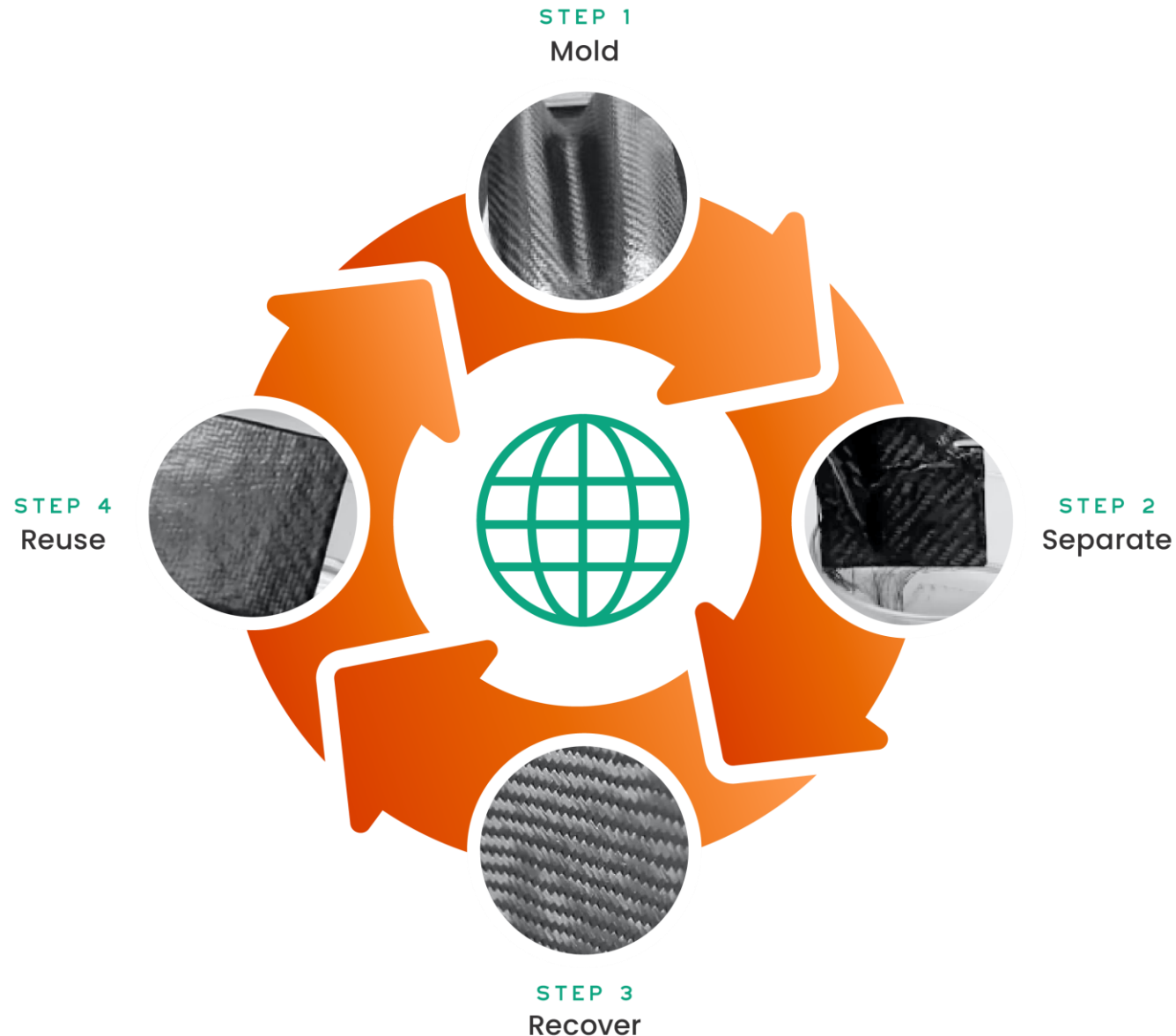
Vitrimer Composites



Thermoplastic Composites



VITRIMERS: INTRINSICALLY RECYCLABLE



Due to the reversible crosslink chemistry in vitrimers, cured vitrimer resins can be depolymerized using chemical precursors to the resin itself. This enables circular recovery and reuse of both resin and fiber.

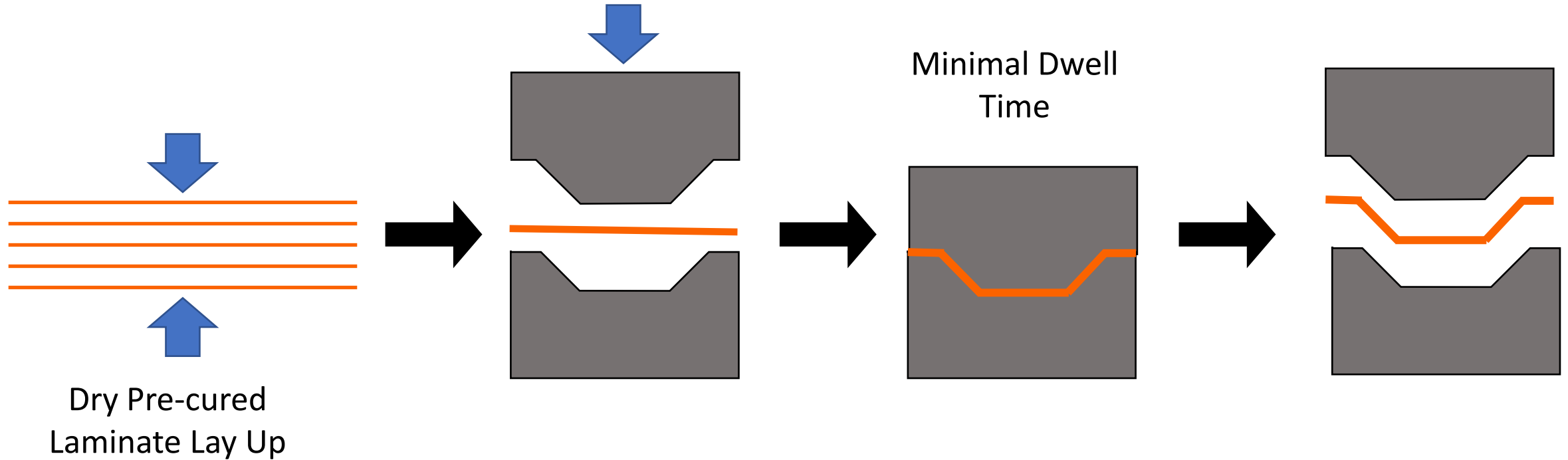
THERMOSET LEVEL STRENGTH

	VITRIMAX T100	VITRIMAX T130	Hexcel Snapcure
Tensile Modulus (GPa)	103	114	118
Ultimate Tensile (GPa)	0.91	1.72	2.2
Flexural modulus (GPa)	50	124	114
Ultimate shear (MPa)	45	70	89
Cured Resin Density (gcm⁻¹)	1.06	1.06	1.3
Tg (°C)	80	130	125
In-mold weld cycle (pre-cured)	30 s-5 min @100C	30 s-5 min @ 180 C	N/A
In-mold Cure cycle	40 min (20 min @160 C)	50 min (15 min @ 180 C)	47 min (2 min isotherm 150C)

The highly crosslinked nature of vitrimers means they exhibit similar mechanical properties to thermoset composites. However, vitrimer composites can be reprocessed after cure. This means that in-mold dwell times can be reduced significantly when compression forming pre-cured vitrimer composites

THERMOPLASTIC-LIKE PROCESSING

Vitrimer-Enabled High Throughput FRC Compression Molding



Vitrimer composite formats



Vitrimer resins are versatile and can be used to replace traditional thermoset resins in some applications, and can be used in place of thermoplastic composites in other applications.

THERMOSET COMPOSITE PROCESSES

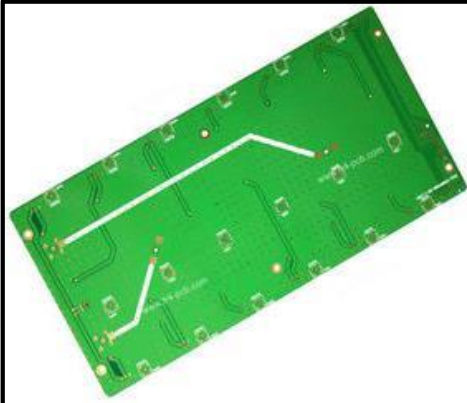
Prepreg- Hotmelt



Sporting Goods, Auto, Aerospace

- Pot life: >2h
- Viscosity: 10k-100k
- Cure: 3-300 min

Prepreg- Solvent



Integrated Circuits, Industrial

- Pot life: >2h
- Viscosity: <5k
- Cure 3-300: min

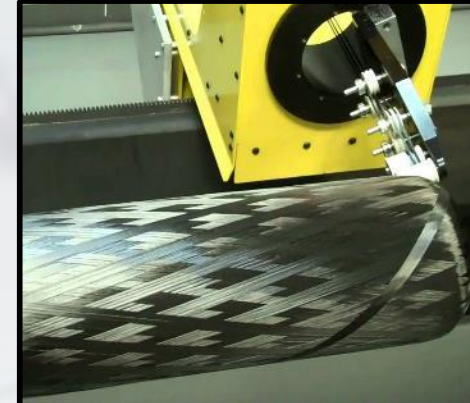
Pultrusion



Industrial, Construction

- Pot life: 10-30min
- Viscosity: <5k
- Cure: 0.5-1.5 min

Towpreg



Compressed Gas Storage

- Pot life: >2h
- Viscosity: 5k-20k
- Cure: 6h

RTM



Automotive, Aerospace, Wind

- Pot life: >2.5 h
- Viscosity: <500
- Cure: 6h



Market Snapshot





Novel Features

- Pre-cured prepreg for infinite shelf life and improved automation
- Circularly recyclable- both chemical and mechanical recycling
- Post cure processing: Composite Welding
- Post cure processing: Reshaping above T_g

Traditional Processing & Performance

- Two-part resin system with tunable viscosity, etc.
- Thermoset Mechanical properties
- B-staged for in-mold cure (if desired)
- Compatible with traditional: prepregging, pultrusion, additive tapes, RTM*





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