



Development of bio-based vitrimer composites for blades

- **EOLIAN Webinar**, 11th December 2025

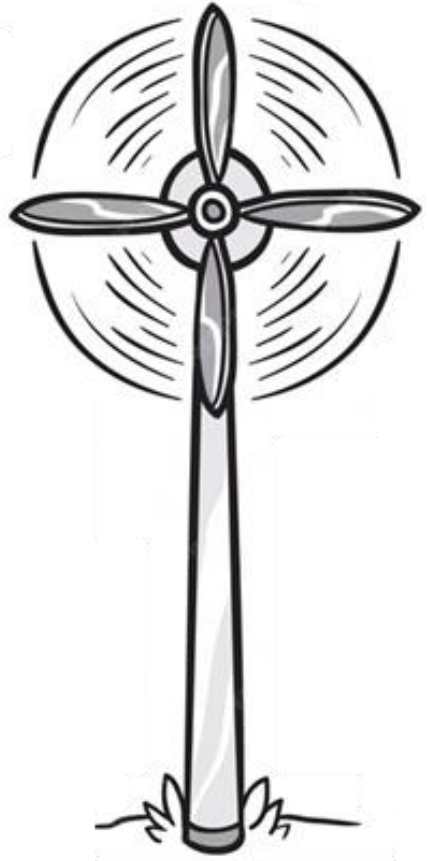
Cristina Monteserin

www.eolian-project.eu

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CONTEXT



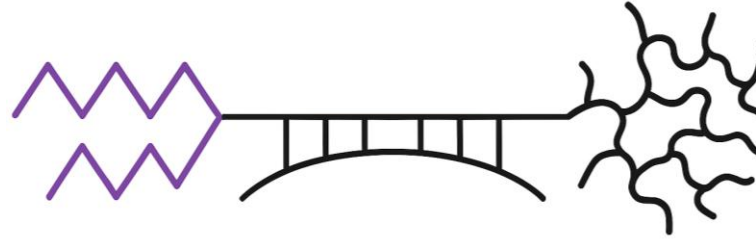
The wind blade manufacturing sector is shifting toward **more sustainable materials**, driven by the need to reduce environmental impact while maintaining structural performance. Growing regulations and the move toward a **circular economy** are intensifying the demand for alternatives to **traditional thermoset composites**.



INTRODUCTION TO VITRIMERS

THERMOPLASTICS

Linear or
branched
chains



- Moderate mechanical performance
- Limited chemical resistance 
- Can be remolded and reshaped
- Recyclable through melting 
- Can be heated until molten
- Generally soluble in suitable solvents

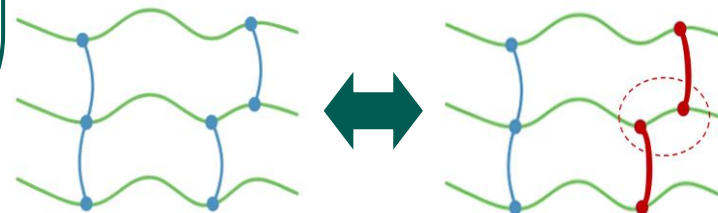
THERMOSETS

Cross-linked 3D
network



- High mechanical strength 
- Excellent chemical resistance
- Thermal and dimensional stability
- Highly resistant to elevated temperatures
- Not melt-recyclable 
- Cannot be remolded once cured
- Insoluble due to cross-linked network

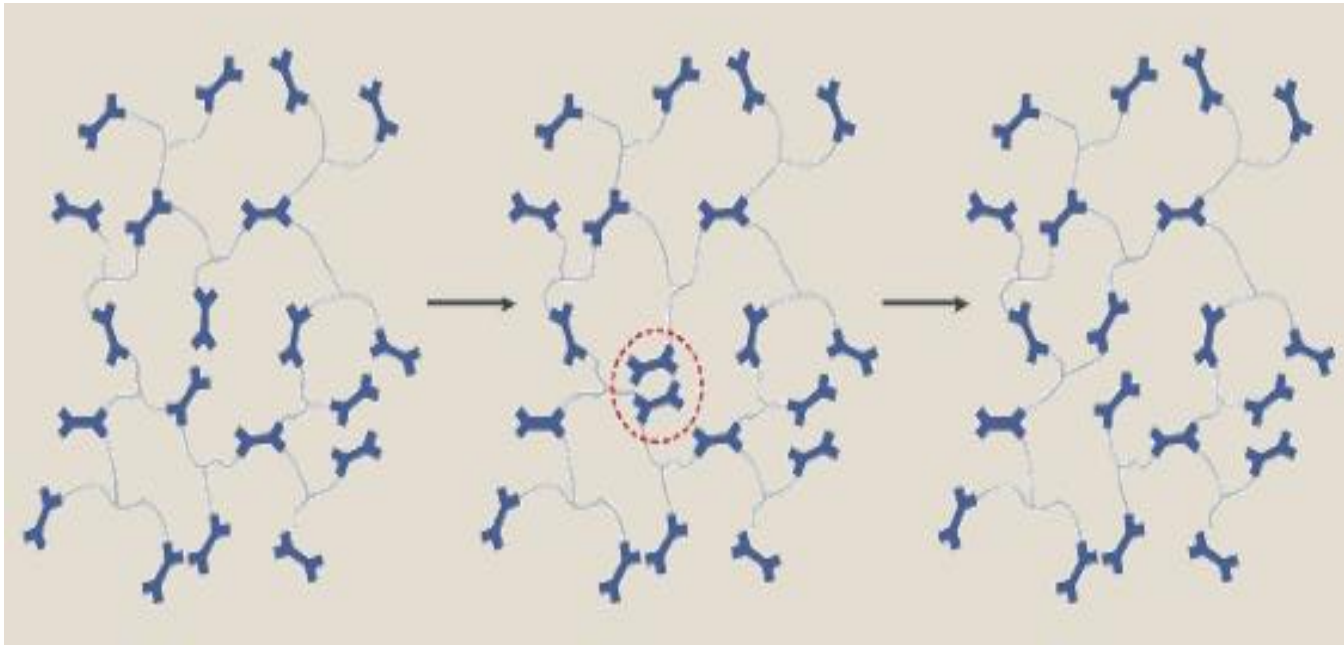
**Covalent Adaptable
Networks (CANs)**



INTRODUCTION TO VITRIMERS

**Dynamic
thermosetting
materials**

Crosslinked networks incorporating
Dynamic Covalent Bonds



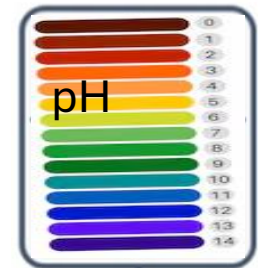
External Stimulus



Temperature



Light



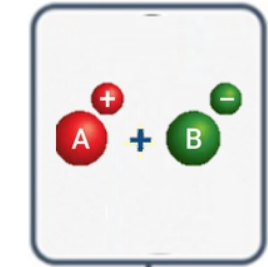
pH Value



Solvent



Humidity

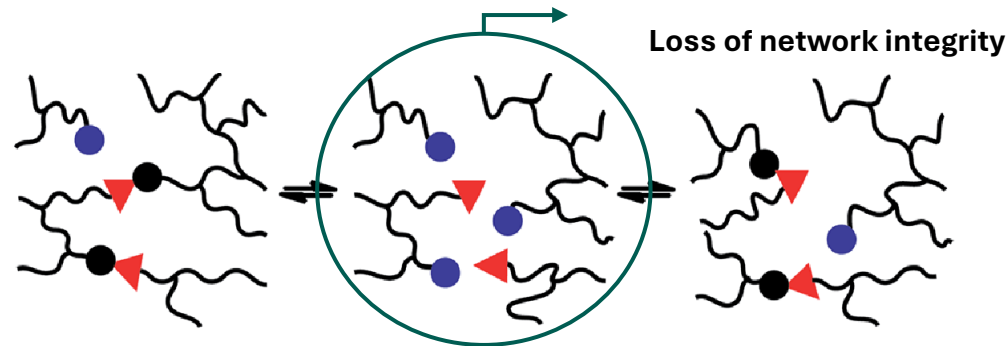


Redox
reaction

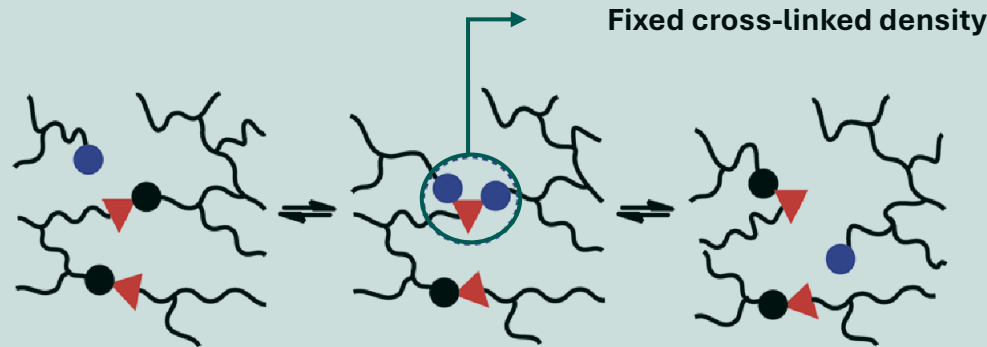
INTRODUCTION TO VITRIMERS

Type of Mechanism

Dissociative CAN

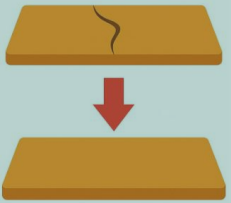


Associative CAN

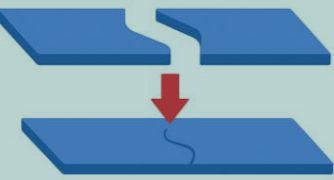


Tunable properties

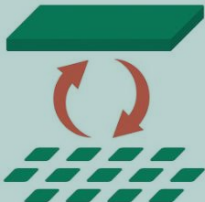
Self-healing capabilities



Reprocessability



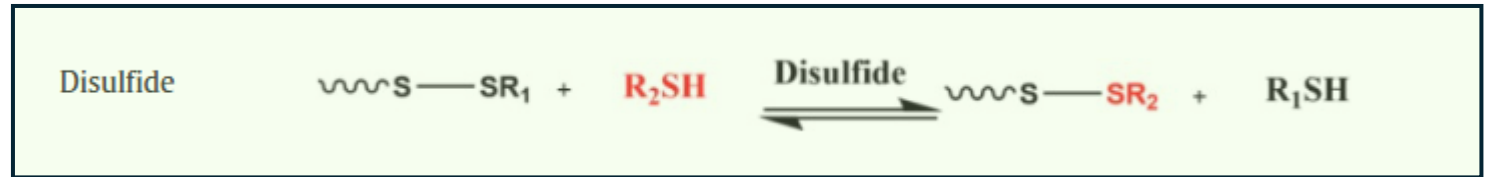
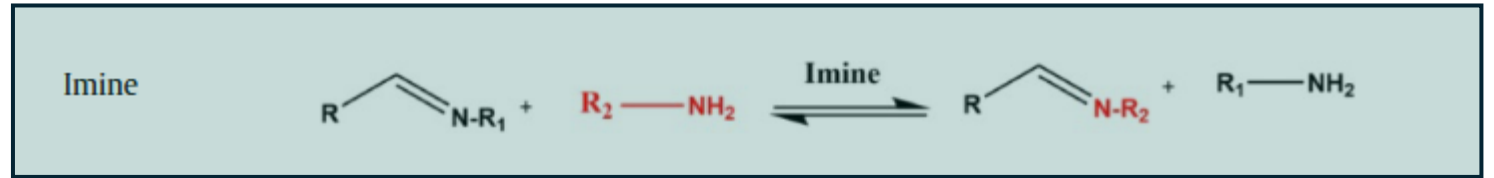
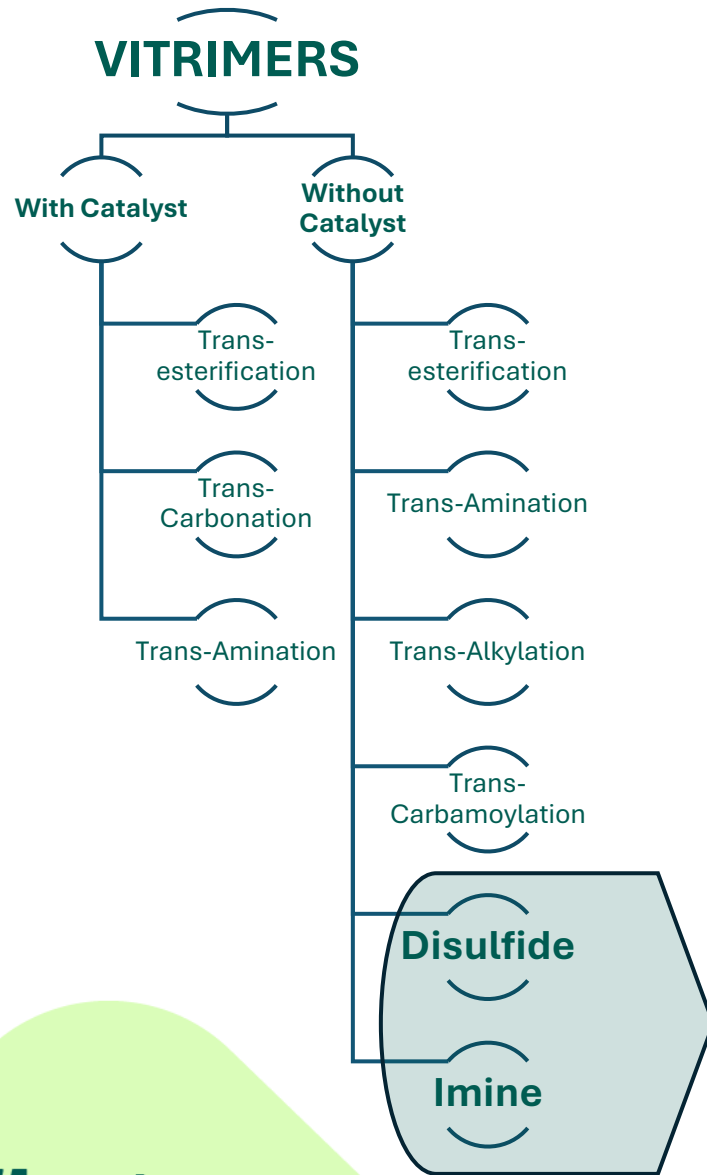
Recyclability



Shape memory



INTRODUCTION TO VITRIMERS



EOLIAN



VITRIMERS based on Imine Bonds



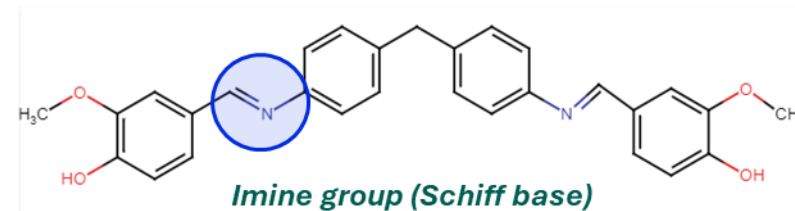
In EOLIAN project, we explored the development of a range of sustainable **epoxy** vitrimers based on a Schiff base obtained by reacting **diamines** and a **bio-based** compound, **vanillin**, with **epoxy resins derived from oils**, which are shown to be reprocessable and recyclable under soft conditions.

Step 1: Dynamic Hardener synthesis

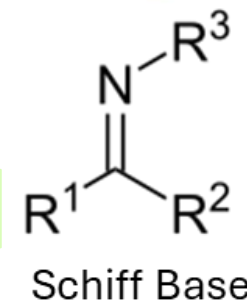


Vanillin

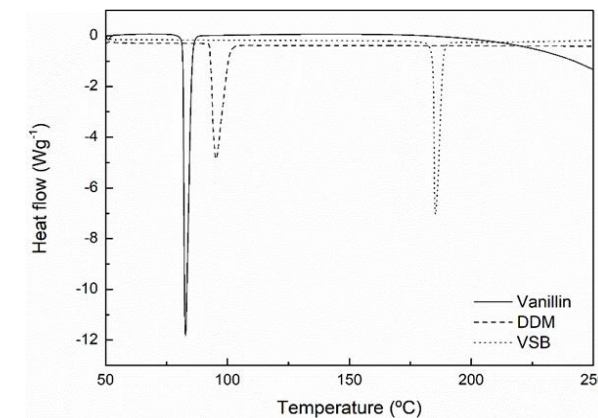
4,4'-diaminodiphenylmethane
(DDM)



Imine group (Schiff base)



Schiff Base

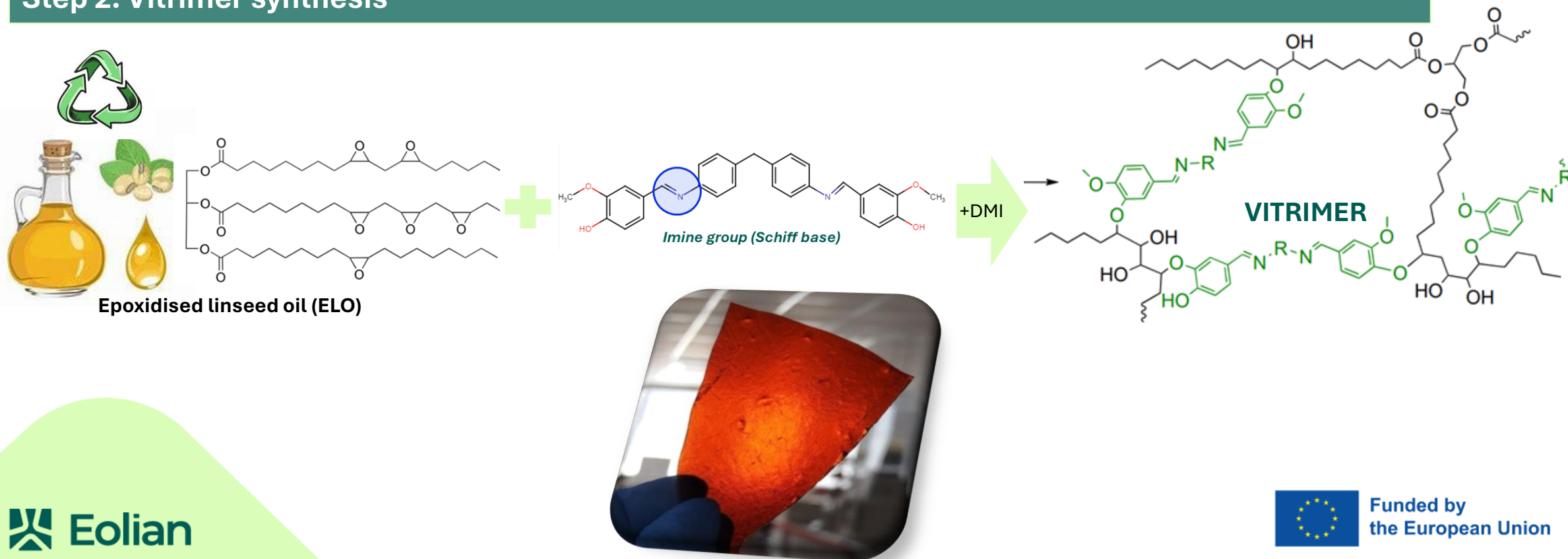


VITRIMERS based on Imine Bonds



In EOLIAN project, we explored the development of a range of sustainable **epoxy** vitrimers based on a Schiff base obtained by reacting **diamines** and a **bio-based** compound, **vanillin**, with **epoxy resins derived from oils**, which are shown to be reprocessable and recyclable under soft conditions.

Step 2: Vitrimer synthesis



VITRIMERS based on Imine Bonds



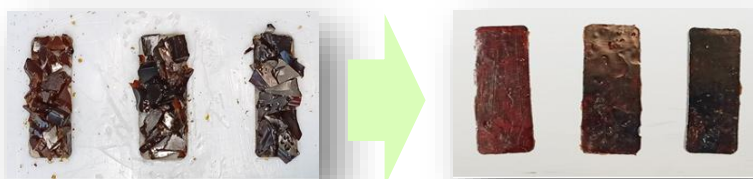
≥ 60 % BIO content



Mechanical and thermal properties
based on requirements



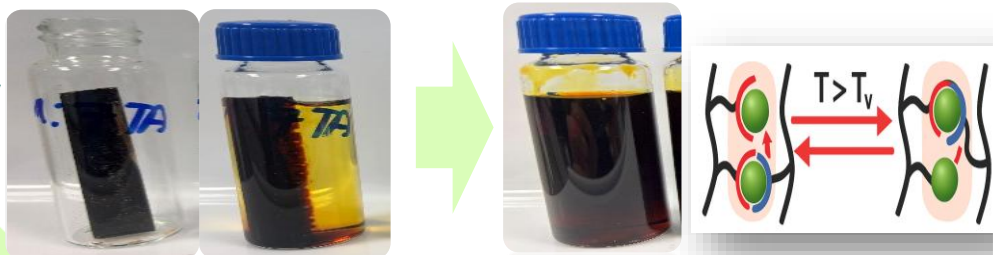
Reprocessability



Repairability



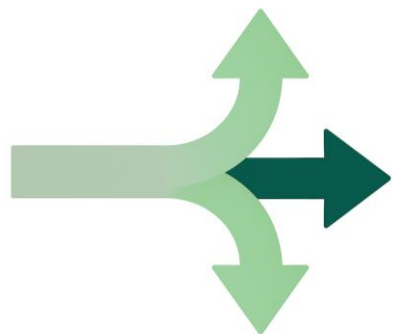
Solubility



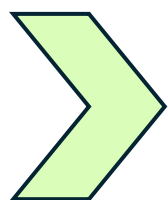
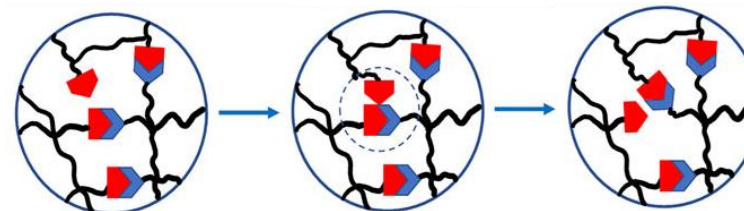
Viscosity

- ✓ VSB-based on diamines with different chemical structures
- ✓ Incorporation of reactive epoxy and/or phenolic diluents
- ✓ Adjusting starting material structures and incorporating diverse epoxy systems

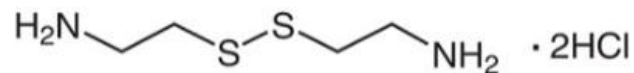
VITRIMERS based on Disulfide Bonds



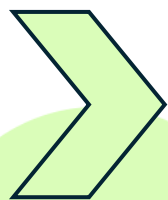
A possible alternative to imine-based vitrimers



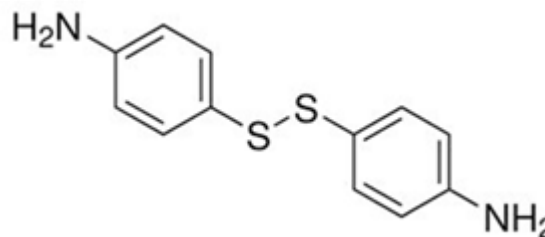
Cystamine



Viscosity
Mechanical / Thermal
properties
Repairability
Reshapability



AFD (4,4'-diaminodifenil
disulfide)



Easily available, easy
processing, more **affordable**
and potentially bio-based
precursor to be used to
formulate epoxy vitrimers for
composite applications



Thank you for your attention!

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them



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