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Development of bio-based vitrimer composites for wind turbine blades

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www.eolian-project.eu

POLITECNICO MILANO 1863

POLYENG LAB

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Development of bio-based vitrimer composites for wind turbine blades

Composite materials are the primary choice for wind turbine blades.

Eolian aims to develop sustainable alternatives to fiberglass creating bio-based composites out of basalt fibers impregnated with a vitrimer matrix.

This combination enables for increased sustainability throughout the entire blades' lifecycle given the innovative properties of vitrimers such as repairing and reshapability.

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Development of bio-based vitrimer composites for wind turbine blades

PoliMI actively collaborates with the project partners contributing in three main fields:

Composites manufacturing

Eolian's goal is to manufacture composites through resin infusion, that is the most spread technique in the wind industry.

Resin and composite testing

Evaluating the performances of the composite and testing the repairing capabilities of the developed formulations is key for the final blade design.

End-of-life management

The capability of vitrimers to be reprocessed at sufficiently high temperature paves the way to EoL strategies as reforming and high-value recycling.

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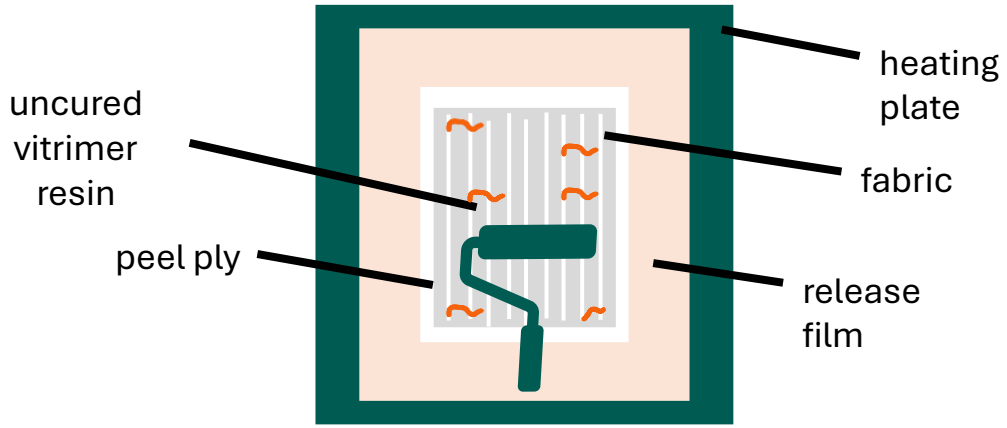
Composites manufacturing



Commercial vitrimeric resins (Mallinda) are too viscous to be infused. For this reason, Polimi's experience with vitrimer composites manufacturing started from hand-layup.

Lately vitrimer infusions have been performed either at moderate temperature (up to 80°C) or even at room temperature, delivering high quality composites with optimized fibers volume fraction and low void content.

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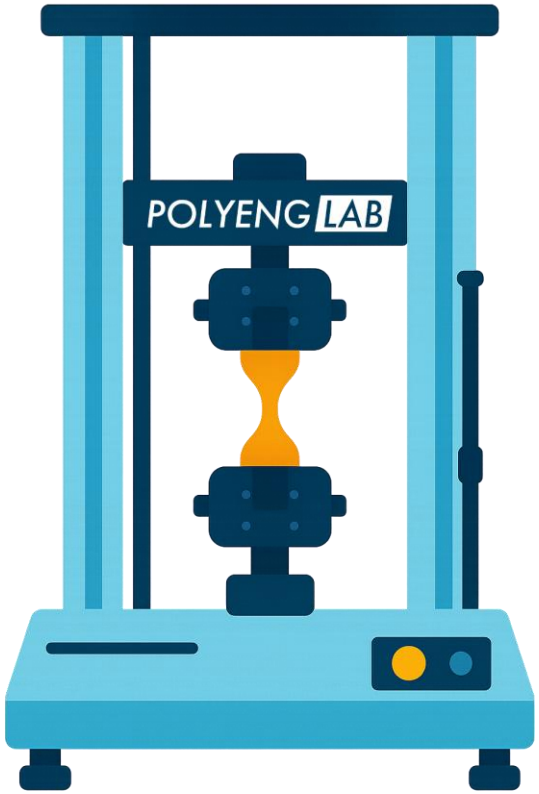
Materials testing

Materials investigation is divided in two macro-categories:

Vitrimer and Vitrimer Matrix Composite Characterization



Assessment of the Vitrimeric Behavior

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Materials testing

Vitrimer and Vitrimer Matrix Composite Characterization

Vitrimer Resin

- Definition of a protocol for the identification of the topology freezing temperature Tv (DMA, TMA).
- Thermal analysis (DSC, TGA) to characterize Tg and thermal stability.
- Mechanical testing on neat resin in different stress states and temperatures.

Composite

- Mechanical Characterization (tensile, flexural properties)
- Fracture Behavior (interlaminar fracture toughness)

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Materials testing

Vitrimer Resin and Composite

- Design of Reprocessing Processes exploiting Vitrimer Properties (Mechanical Recycling and Reshaping)
- Assessment of the efficiency of the processes through quantitative methods
- Characterization of the material obtained from Mechanical Recycling and from the Reshaping
- Evaluation of Property Retain after repeated healing

Assessment of the Vitrimeric Behavior

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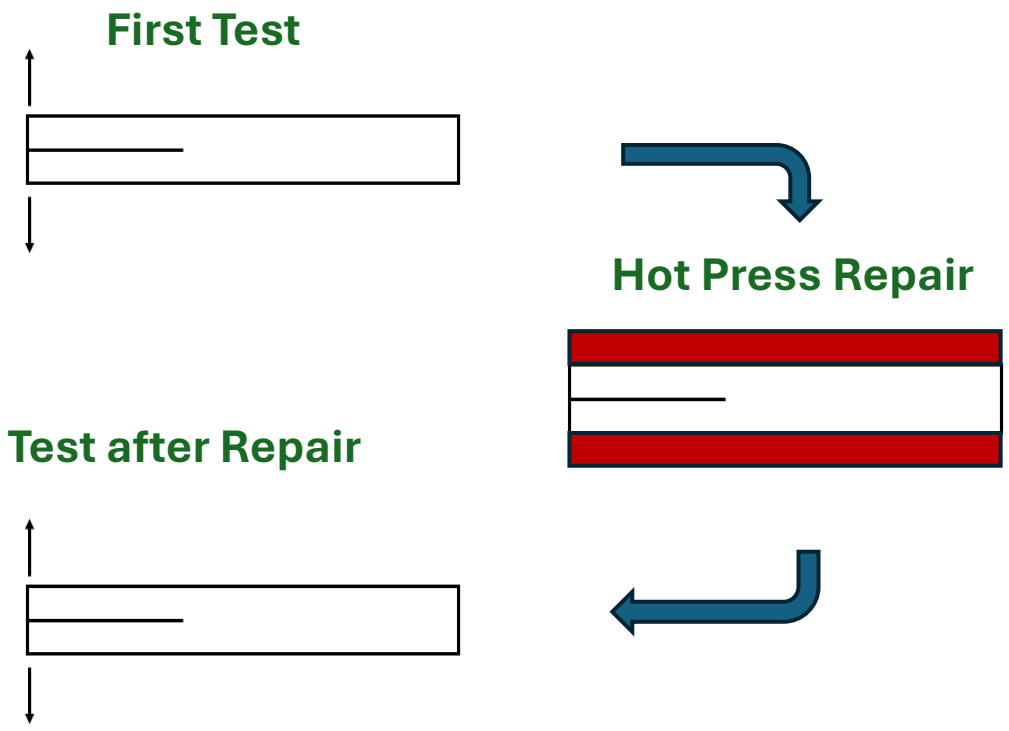
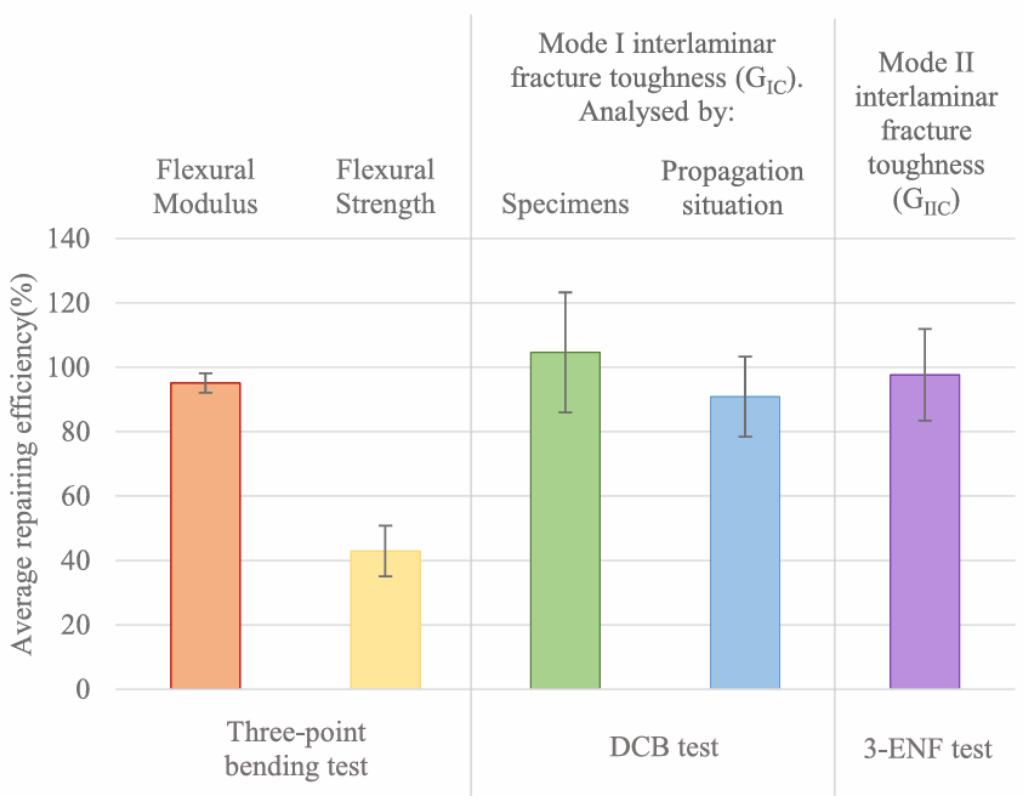
Materials testing

Composite Repairability Assessment





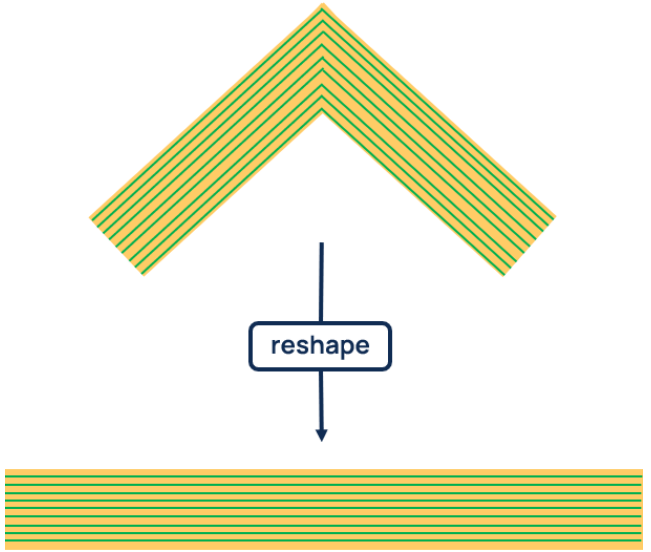
A. Lopez-Olmedo et al. Composites Part B (2025)

End-of-life management

Vitrimer matrices increase the End-of-life options

Reshaping:

Flat plates can be thermoformed into curved surfaces, or viceversa curved plates can be flatten to prepare the material for further processing or a secondary use.



Mechanical recycling:

The composite can be shredded into different size fragments, costituting a bulk molding compound to be hot pressed without the need of phase separation.

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