

## Mild solvolysis for fiber-reinforced composites

Extracting high-value materials from complex end-of-life parts

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## The state of the art

Structural and high-performance fiber-reinforced composites (**thermosets**):

- GFRCs  $\rightarrow$  crosslinked unsaturated polyesters, vinyl esters
- CFRCs  $\rightarrow$  epoxies



RE

- high strength-to-weight ratio
- dimensional stability
- durability





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Challenging recyclability



- Recovery of reinforcing fibers
- Recovery of matrix material
- Second-life applications



## **Composite waste generation**

Increasing volumes of fiber-reinforced **composite waste** generated annually:

wind

RE

- aerospace
- automotive



Decommissioned Blade weight (including Repowering)



Source: WindEurope

## **Composite recycling: current status**

#### End-of-life scenarios for fiber-reinforced composites



#### **Technology readiness levels**:

RE

- Mechanical shredding, combustion (co-processing), pyrolysis  $\rightarrow$  TRL9
- HVF, chemical recycling  $\rightarrow$  TRL4-6





**Current limitations** of recycling technologies:

- High levels of **gas emissions**
- Marginal **economic** profitability
- **Poor quality** of reclaimed materials (fibers, matrix)
- High-pressure processes
- Highly acidic/alkaline process conditions
  - $\rightarrow$  special reactor design and components





## The problem

R

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   → special reactor design and components









## Flexible. Mild. Circular.

## The recycling process for fiber-reinforced composites.





No pre-treatments on the EoL part	Floviblo
• Universal process	FIEXIBLE





<ul><li>No pre-treatments on the EoL part</li><li>Universal process</li></ul>		Flexible
<ul> <li>Process conditions:         <ul> <li>temperatures &lt; 250 °C</li> <li>atmospheric pressure</li> <li>neutral/slightly acidic conditions</li> <li>low-cost commercially-available catalysts</li> </ul> </li> </ul>	standard reactor design → lower CapEx	Mild





<ul> <li>No pre-treatments on the EoL part</li> <li>Universal process</li> </ul>	Flexible
<ul> <li>Process conditions:         <ul> <li>temperatures &lt; 250 °C</li> <li>atmospheric pressure</li> <li>neutral/slightly acidic conditions</li> <li>low-cost commercially-available catalysts</li> </ul> </li> </ul>	Mild
<ul> <li>Bioderived solvents</li> <li>Recovery of solvent and catalyst</li> <li>Recovery of fibrous reinforcement with preserved mechanical properties</li> <li>Recovery of oligomeric organic fraction retaining high chemical functionality</li> </ul>	Circular















P<sub>amb</sub>, T < 250 °C, t

































"Process of recovery of fibers and of an organic oligomeric fraction from polymer-matrix composite materials"

(Processo di recupero di fibre e di una frazione organica oligomerica da materiale composito a matrice polimerica)

G. Griffini, S. Turri, V. De Fabritiis, L. Matta

**Italian patent application** for industrial invention (P08221/IT, priority date: 05.12.2024)  $\rightarrow$  extension to other countries under consideration









Demonstration and validation on larger scale equipment

- Process **optimization**
- Economics and **business** plan







# Thank you for your kind attention!



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