

Mild chemical recycling of carbon fiber reinforced polymers with epoxy-amine networks

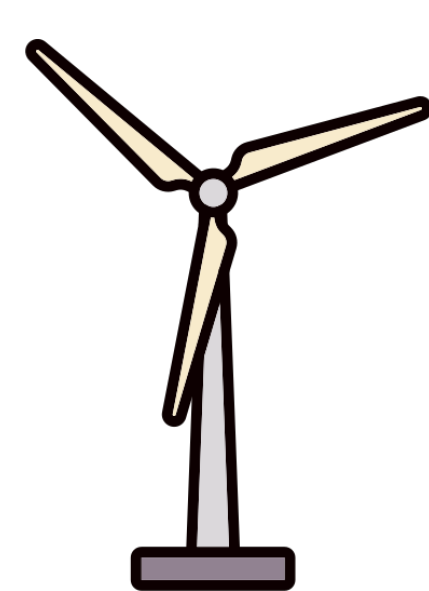


POLITECNICO
MILANO 1863

[ChIP]₂Lab

Valeria De Fabritiis, Leonardo Matta, Gianmarco Griffini, Stefano Turri

¹ Politecnico di Milano - Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Milan, Italy



Fiber-reinforced composites, mainly made of unsaturated polyesters and epoxy thermosets, reinforced with carbon or glass fibers, combine:

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



Challenging recyclability

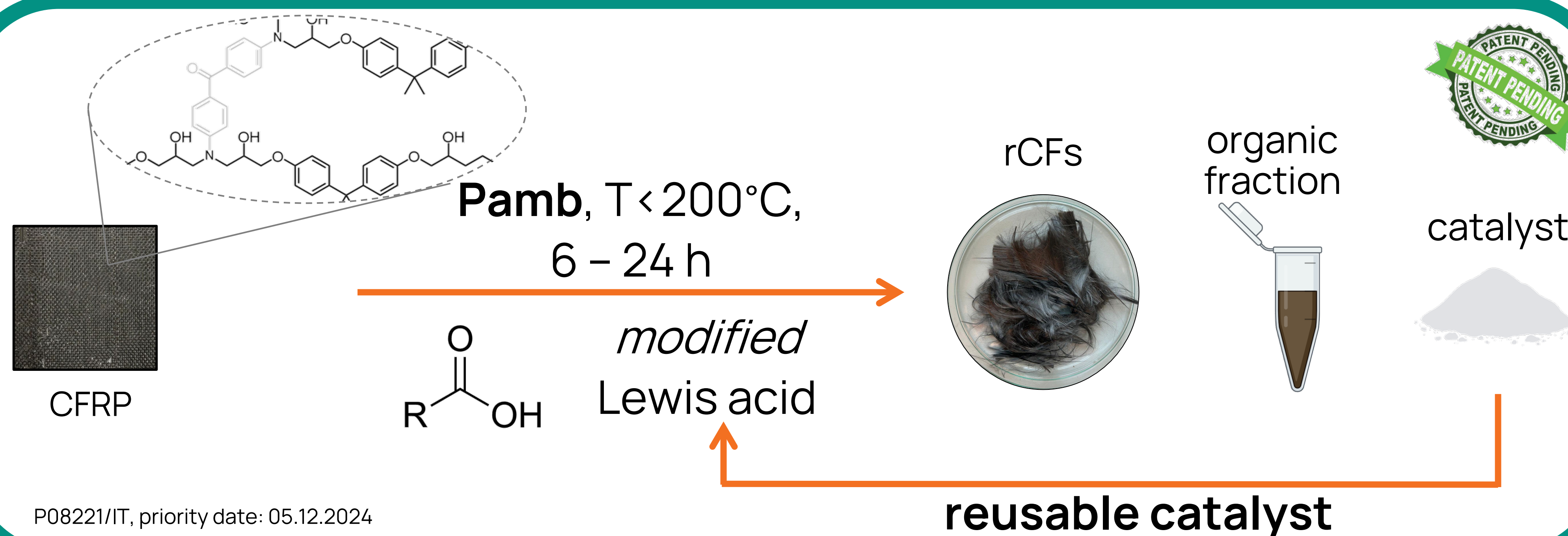


- sustainable solvents
- ordinary P and T < 200°C
- flexible and scalable process

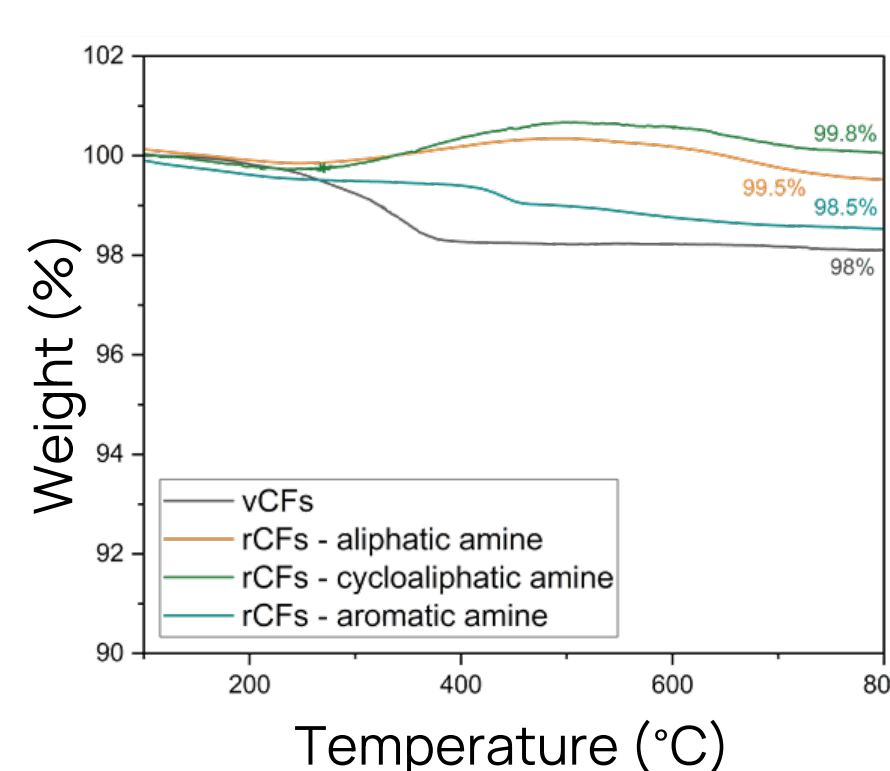
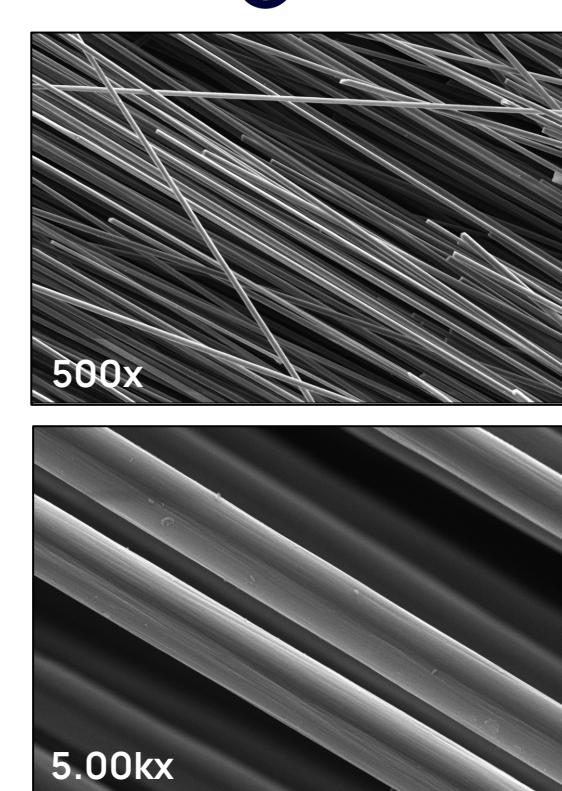
CATALYST-ASSISTED
GREEN SOLVOLYSIS

Advanced recycling methods to recover and valorize:

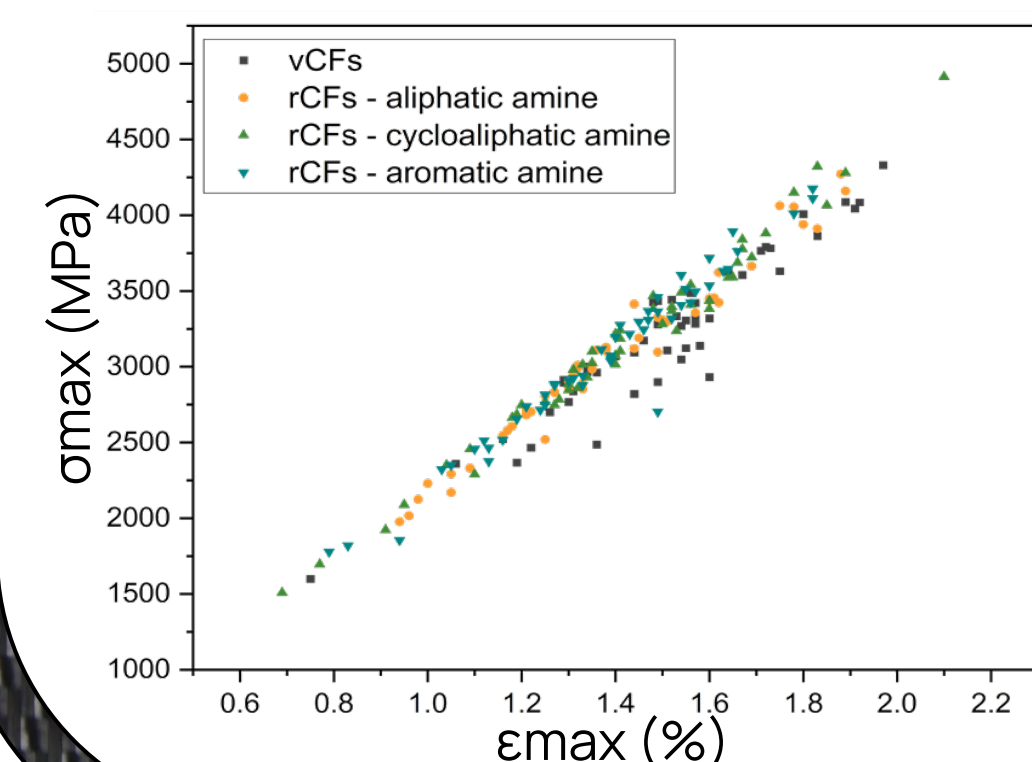
- clean and intact fibers
- organic fraction with residual functionality



CHARACTERIZATION OF RECYCLED CF

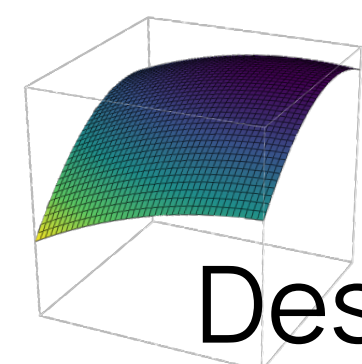


	E (GPa)	σ_{max} (GPa)	ϵ_{break} (%)	diameter (μm)
rCF	212.55 \pm 10.51	2.78 \pm 0.50	1.30 \pm 0.22	7.69 \pm 0.51
rCF	220.10 \pm 6.07	3.17 \pm 0.66	1.42 \pm 0.28	7.59 \pm 0.38
rCF	221.11 \pm 8.12	3.07 \pm 0.52	1.38 \pm 0.24	7.33 \pm 0.40
vCF	211.34 \pm 10.67	3.20 \pm 0.52	1.50 \pm 0.23	7.55 \pm 0.38

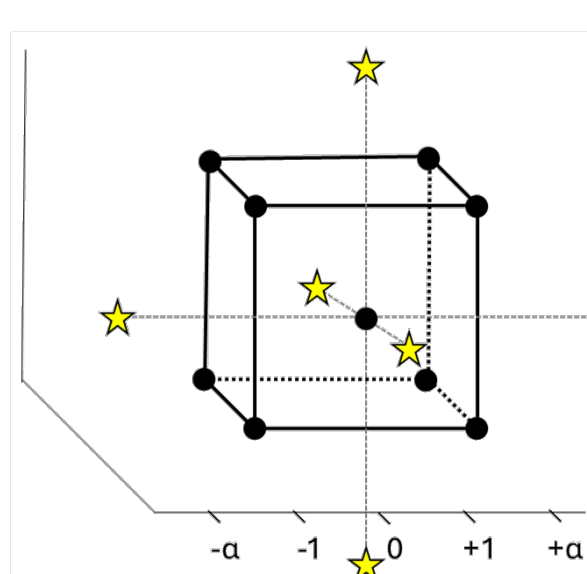


rCFs retain >95% of their pristine mechanical properties

PROCESS OPTIMIZATION



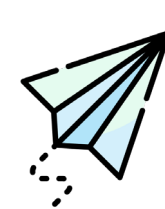
Design of Experiments



Central composite design

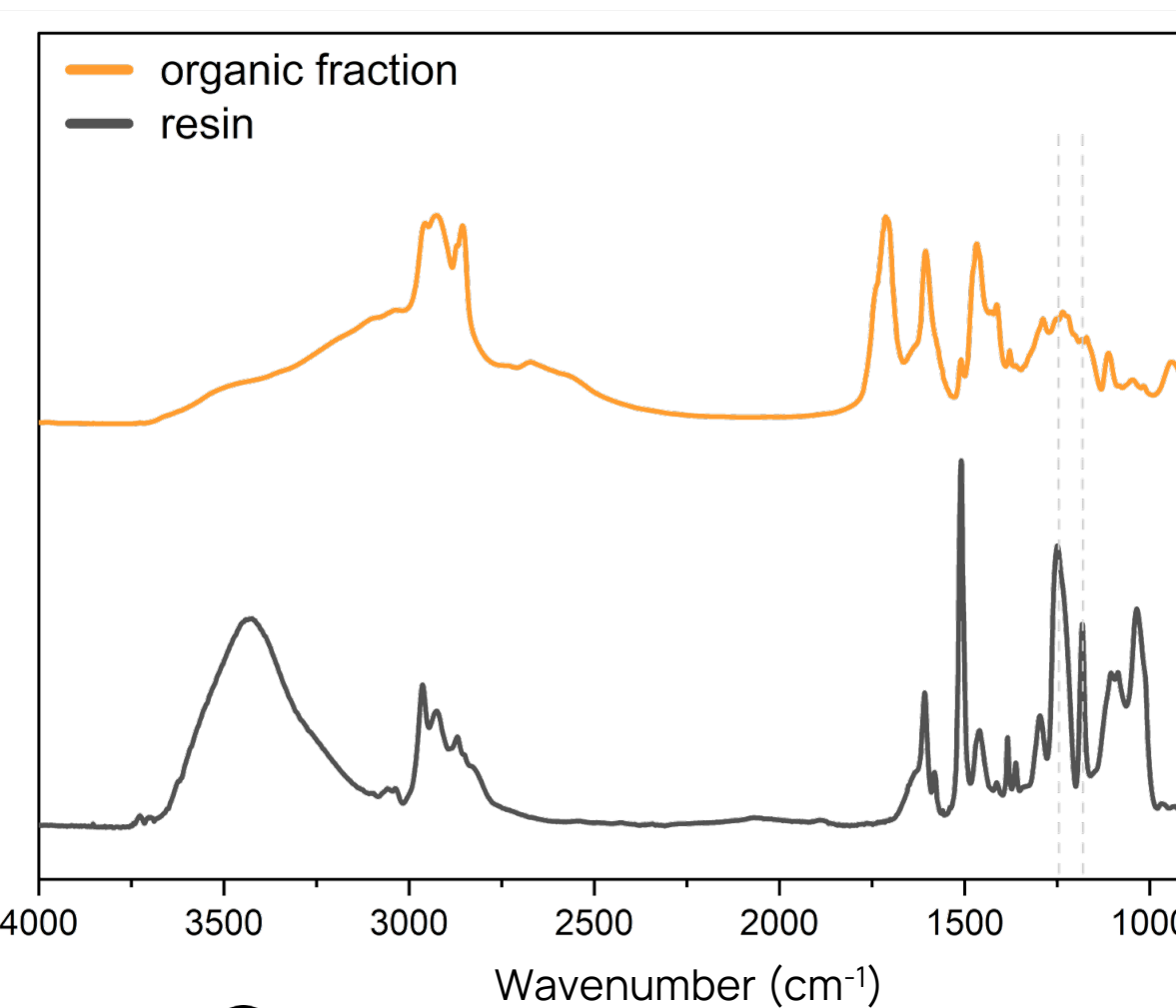
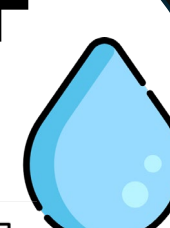
Factors under study	Levels				
	- α	-1	0	+1	+ α
Catalyst concentration, X ₁ (%wt)	2.5	5	7.5	10	12.5
Resin concentration, X ₂ (%wt)	5.5	7	8.5	10	11.5
Temperature, X ₃ (°C)	190	200	210	220	230
Reaction time, X ₄ (h)	6	12	18	24	30

Optimal reaction conditions to obtain complete degradation of the polymeric matrix

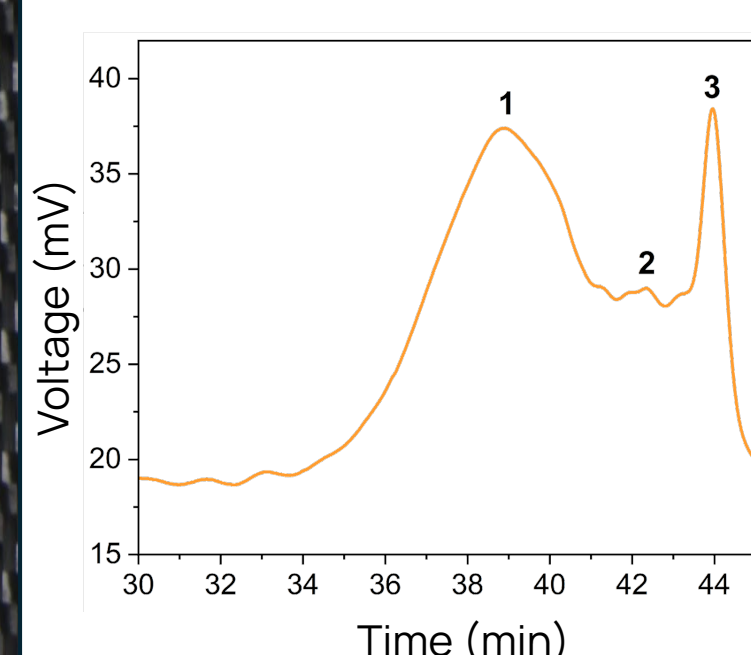


De Fabritiis, V., Matta, L., Griffini, G., & Turri, S. (2025). *Cleaner Engineering and Technology*, 100988.

CHARACTERIZATION OF ORGANIC FRACTION



selective cleavage of C-N and C-O bonds



Peak	Mn (g/mol)	Mw (g/mol)	D
1	1645	2400	1.46
2	470	480	1.02
3	240	250	1.04

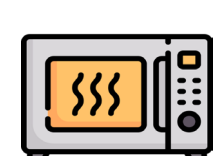


reusable oligomeric fraction for second-generation CFRP

CONCLUSIONS AND FUTURE STEPS



- flexible, mild and optimized process
- clean rCF with excellent mechanical properties
- organic fraction with residual functional groups



Microwave-assisted solvolysis



Organic fraction valorization



Process scale-up



SUCCESSFUL FIBER LIBERATION ON REAL EOL MATERIALS



racket fragments



wind turbine fragments



RE

