



Optimizing the vacuum assisted resin infusion process for carbon fiber laminates with Akelite resin

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MATRICES FOR SUSTAINABLE COMPOSITES

Bio-based matrices

- ❖ Commercial grades with up to 30 % bio-based
- ❖ Similar properties
- ❖ Limited recyclability

Vitrimers

- ❖ Dynamic covalent bonds
- ❖ Reprocessability
- ❖ Recyclable

Thermoplastic

- ❖ Reprocessability
- ❖ Recyclable
- ❖ High viscosity → reactive systems

AKELITE RESIN

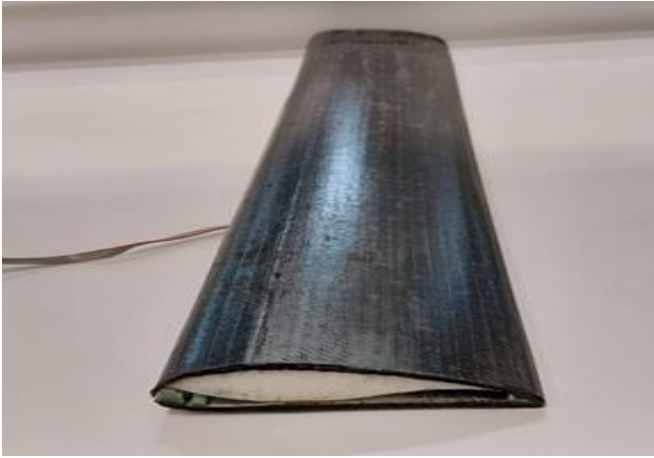


- ❖ Patented by CSIC, acrylic based resin
- ❖ 100% Circular – recover both fibers and matrix
- ❖ Conventional fabrication processes: RTM, VARI...
- ❖ Controlled and mild processing parameters
- ❖ Easy impregnation of commercial fibers
- ❖ Production of semi-elaborates

Laminate	% FC weight	Thickness (mm)	Flexural				ILSS (MPa)
			Longitudinal		Transversal		
			σ_{max} (MPa)	E (GPa)	σ_{max} (MPa)	E (GPa)	
Akelite	65,8	1,4 ± 0,1	1.045 ± 59	59 ± 4	79 ± 5	5,1 ± 0,5	58 ± 1
Epoxy (Resoltech)	69,6	1,4 ± 0,1	957 ± 67	59 ± 7	90 ± 5	6,6 ± 0,8	50 ± 3

AKELITE RESIN

Prototypes



Thermoforming



T= 150°C +
light pressure



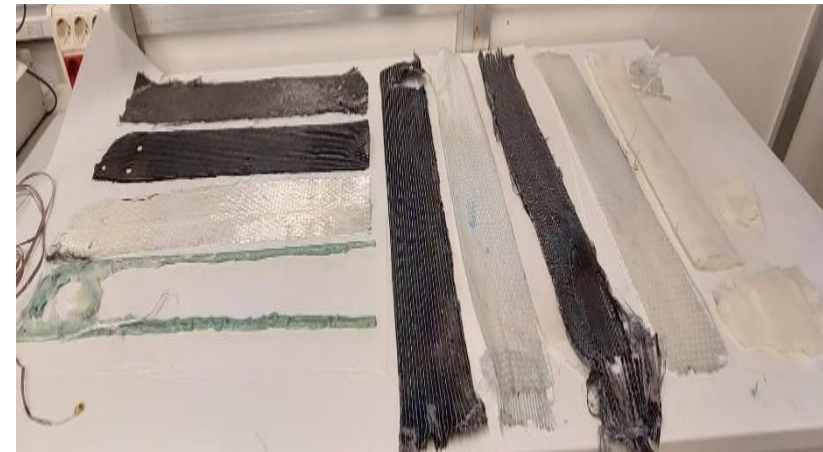
RECYCLING

Method Immerse the laminate in acetone.

Time 18 hours.

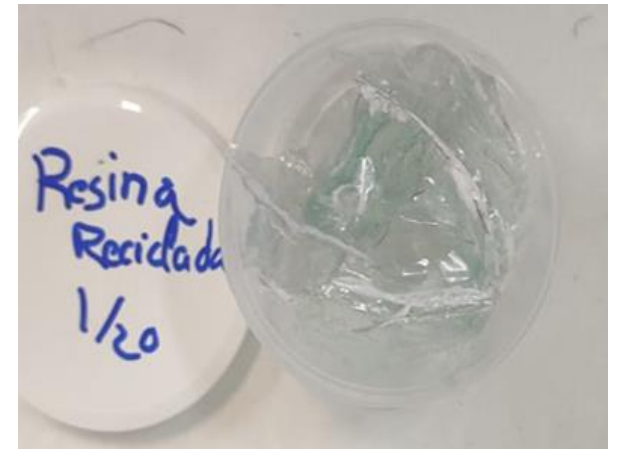
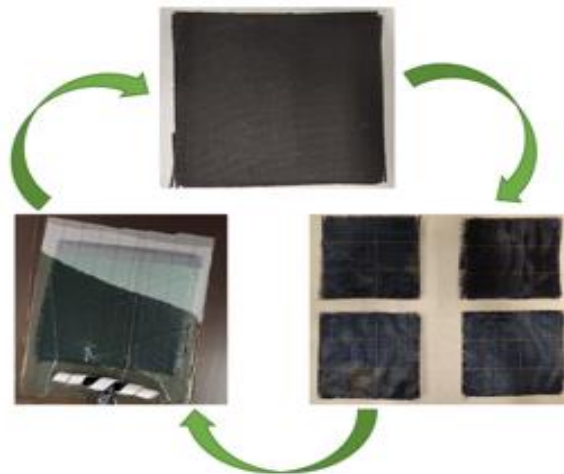
Result The carbon fiber panels could be separated, managing to remove more than 95% of the resin they had.

Acetone and resin recovery Evaporation - condensation process: rotary evaporator



RESULTS RECYCLING

Test	Virgin		Recycling	
	Longitudinal	Transversal	Longitudinal	Transversal
Flexural				
σ (MPa)	488 ± 92	293 ± 99	469 ± 59	346 ± 75
E (GPa)	23 ± 7	15 ± 6	24 ± 3	16 ± 4
ILSS (MPa)	32 ± 2		26 ± 6	



VARI OPTIMIZATION



Stage	Temperature, °C	Time, h	PB, %	Vacuum, %
1	70	2	1	100
	70	2	2	100
	70	2	3	100
2	70	2	3	80
3	60	2	3	100
	70 + 80	2 + 1	3	100

- ❖ Economical
- ❖ High fiber content
- ❖ Large dimensions



VARI OPTIMIZATION

Stage	Laminate	Flexural				ILSS (MPa)
		Longitudinal		Transversal		
		σ_{\max} (MPa)	E (GPa)	σ_{\max} (MPa)	E (GPa)	
1	1-2	529.2 ± 59.3	44.6 ± 17.2	60.1 ± 4.0	1.4 ± 0.6	45.2 ± 2.7
	3-4	879.2 ± 35.0	54.9 ± 5.0	85.5 ± 8.0	2.7 ± 0.4	58.5 ± 2.4
	5-6	927.8 ± 72.0	57.0 ± 3.2	89.7 ± 7.4	2.4 ± 0.4	57.8 ± 4.3
2	7-8	856.1 ± 27.2	51.6 ± 5.6	69.7 ± 4.6	3.0 ± 0.4	53.0 ± 5.7
3	9-10	732.4 ± 62.5	54.0 ± 5.3	78.0 ± 2.5	2.0 ± 0.7	57.5 ± 3.3
	11-12	983.9 ± 22.0	52.7 ± 5.5	81.2 ± 6.0	2.9 ± 0.4	59.2 ± 1.9

Laminates

- ❖ UD carbon fiber 12K, 340 g/m² weight.
- ❖ 20 x 11 cm laminates and 4 plies (45 μm thickness).
- ❖ 2 laminates per condition.

Characterization

- ❖ 3P bending in longitudinal and transverse - UNE-EN ISO 178:2020.
- ❖ Interlaminar shear strength (ILSS) - UNE-EN ISO 14130:2003.

CONCLUSIONS

- ❖ The optimal conditions for manufacturing carbon fiber laminates with Akelite resin were 70°C for two hours, 100% vacuum and with 3% initiator.
- ❖ Recycling for laminates with Akelite resin is simple and fibre and resin can be recovered in addition to the solvent used.
- ❖ The property values obtained were very good and capable of competing with laminates made with thermoset matrices.
- ❖ Replace the carbon fiber reinforcement with natural fibers such as line or basalt.

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