SUSTAINABLE COMPOSITES FOR CABIN MONUMENTS – RECYCLING OF RESINS WITH TAILORED FST PROPERTIES

Jan Sam Bobby[1,3], Alexandra Kühn[1], Maximillian Jux[2], Thorsten Mahrholz[2], Ulrich Krause[3], Steffen Opitz[1], **Souvik Chakraborty[1]**

[1] Dept. Sustainability Technologies, Institute of Lightweight Systems, German Aerospace Center (DLR), Lilienthalplatz 7, 38108 Braunschweig, Germany
[2] Dept. Multifunctional Materials, Institute of Lightweight Systems, German Aerospace Center (DLR), Lilienthalplatz 7, 38108 Braunschweig, Germany.
[3] Faculty of Process and Systems Engineering, Institute of Apparatus and Environmental Engineering, Otto-von-Guericke-Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany.

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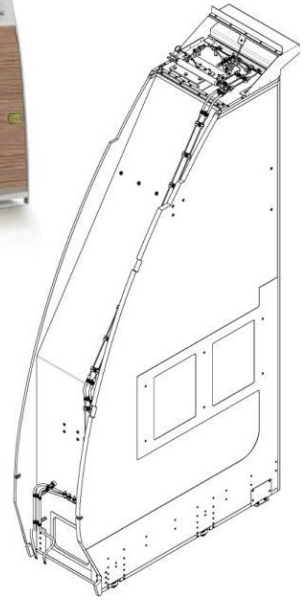
https://www.hangar74.com/en/products/airline-trolley-silver

Introduction



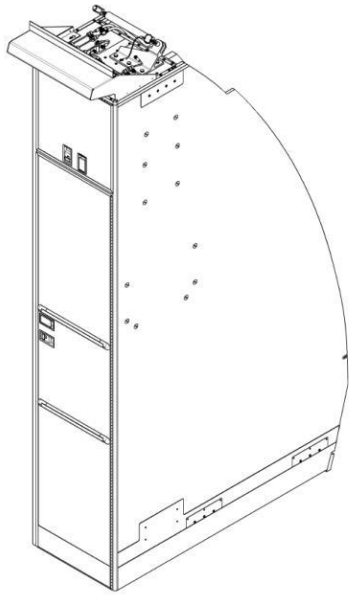


Photo credit: SAFRAN Cabins Germany GmbH

Material constituents:

- GFRP based Sandwich
  - Epoxy or Phenolic
  - Aramid core

Challenge: Repair and recycle

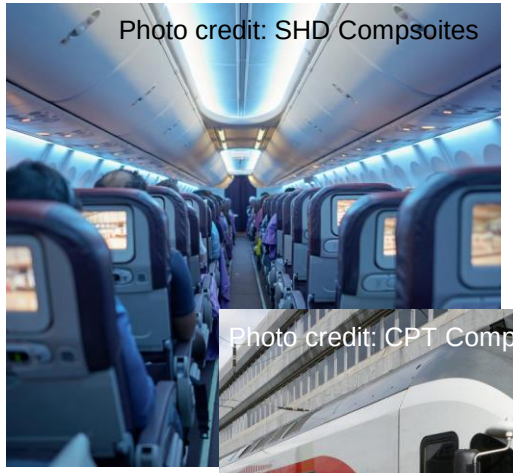


Photo credit: SHD Compsoites

Photo credit: CPT Composites

A few domains of flame retardants as additives

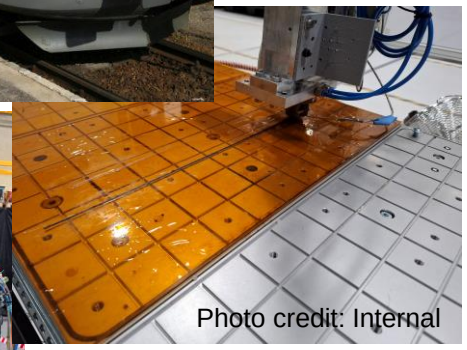


Photo credit: Internal

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CirKle: ReCycling Werkstoffe für Flugzeug-Kabinenbauteile

Recycling materials for aircraft cabin components

Processing
Bulk Composites

Federal Ministry for Economic Affairs and Energy

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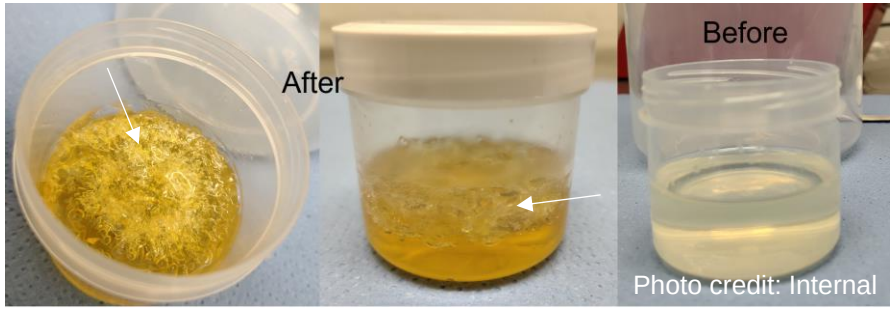
Resins systems in use

Resin System	Manufacturer	Mixing ratio (wt)	Cure Schedule
RIMR 035c + RIMH 037	Westlake Epoxy	100 : 28	80°C / 5hrs
Elium 188XO + Perkadox GB50X	Arkema + Nouryon	100 : 2.5	RT overnight
Recyclamine 033R + 040H	Aditya Birla Advanced Materials	100 : 40	80°C / 25min + 140°C / 4 hrs

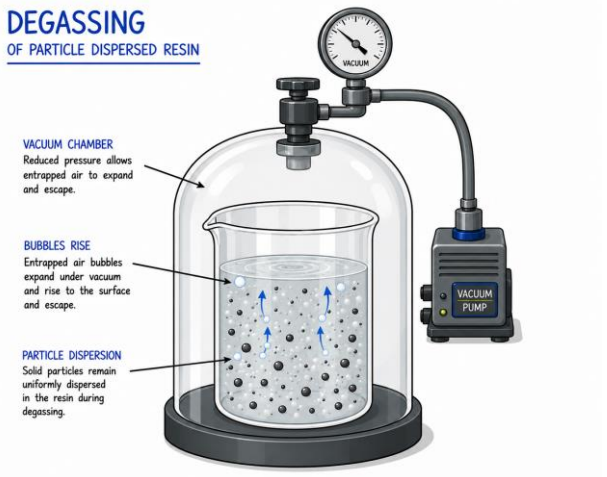
Flame retardant: ATH based S-11 (10wt%) except for reference epoxy (20wt% ATH).

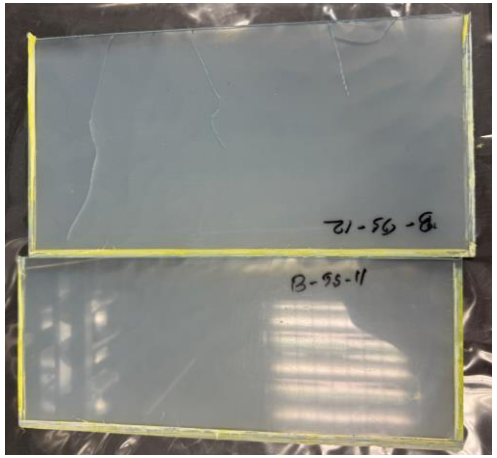


Visual of Elium before and after curing

Cured in Open Mould

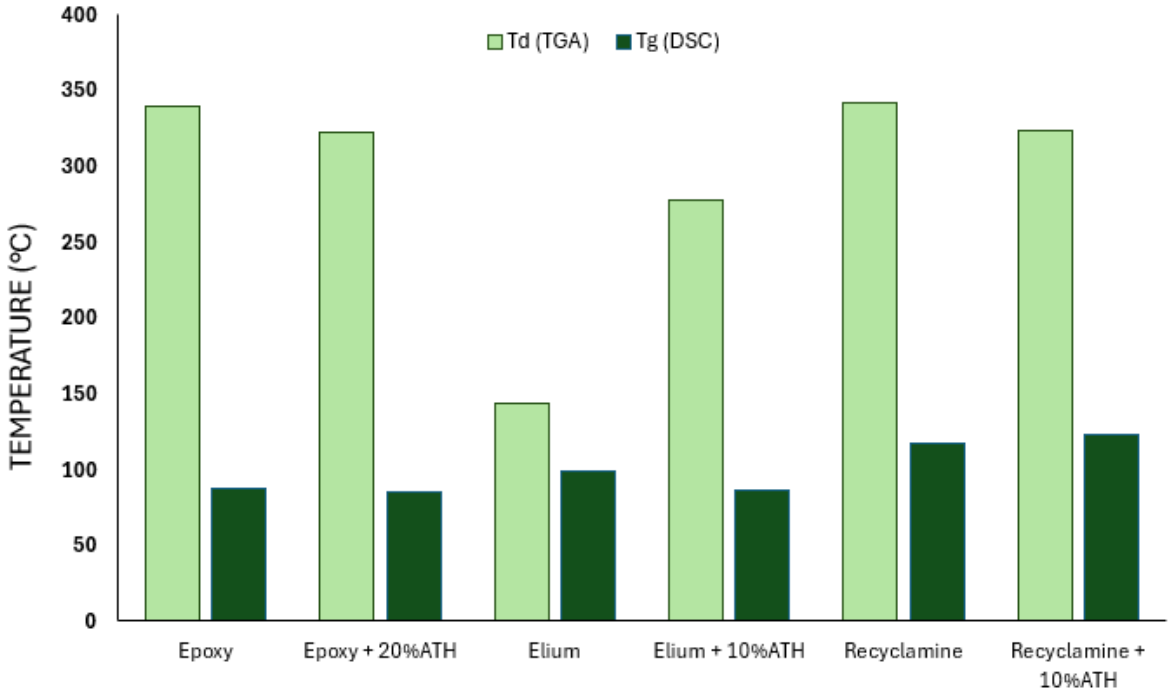
Process steps





AI generated impression: Stirring + degassing

Bulk Response
Thermal performance: DSC and TGA



Key Findings

Recycleamine + 10%ATH — Best Tg: 123°C

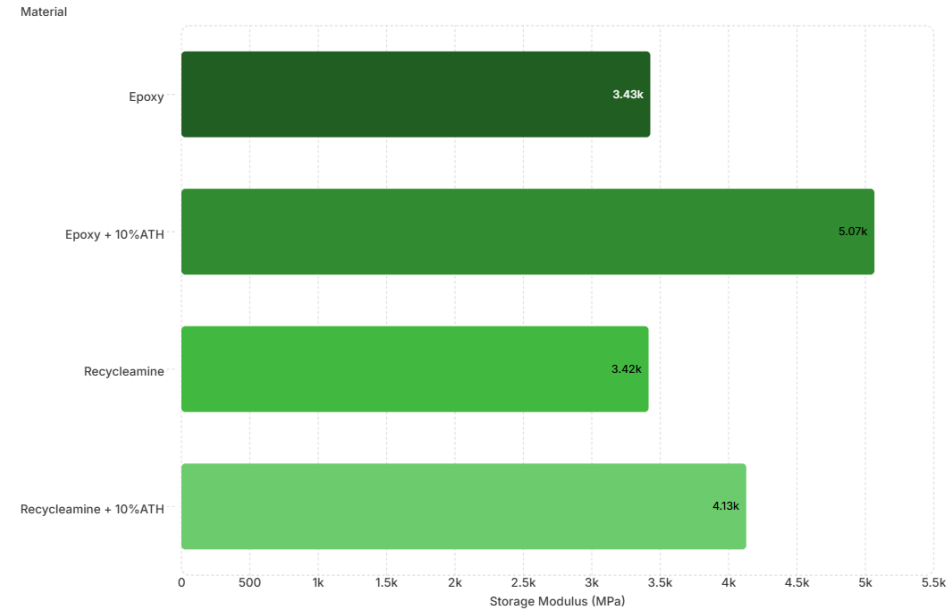
Higher crosslink density restricts polymer chain mobility, elevating glass transition temperature above all systems.

Elium — Lowest Thermal Stability

Methacrylate-based chemistry degrades earlier; however, ATH significantly improved its thermal stability, as ATH releases water during decomposition, which helps delay the degradation process and enhances thermal resistance.

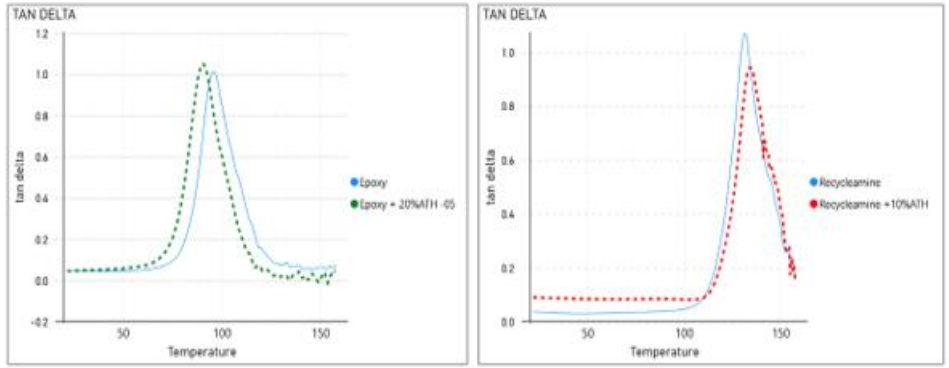
Recyclamine delivers the strongest thermal performance among all investigated systems.

Bulk Response
Thermo-mechanical response: DMA



ATH Reinforcement Effect

ATH acts as a rigid particulate filler, influencing structural stiffness in both resin systems — without significantly compromising thermal performance.



Epoxy + ATH

+43% modulus increase — ATH provides dominant rigid reinforcement in a lower-crosslink matrix.

Recycleamine + ATH

+21% modulus increase — matrix already possesses high intrinsic crosslink density, limiting incremental gain.

Recycling
Routes for additive recovery

Elium currently offers the more straightforward recycling pathway, though Recycleamine delivers superior in-service performance [1].

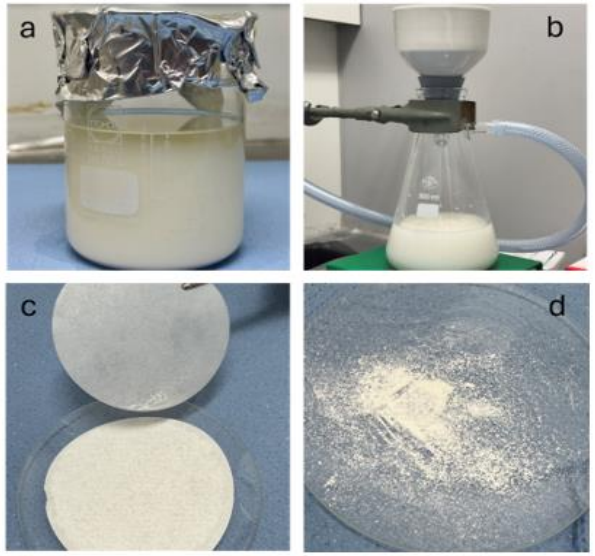


Fig 6: (a) Initial state of the sample after 24 h in acetone, (b) filtration setup, (c) deposits on filter paper, (d) scraped particles from filter paper.

The Engineering Challenge

System	Performance	Recyclability
Elium	Moderate	Excellent
Recycleamine	Excellent	Challenging

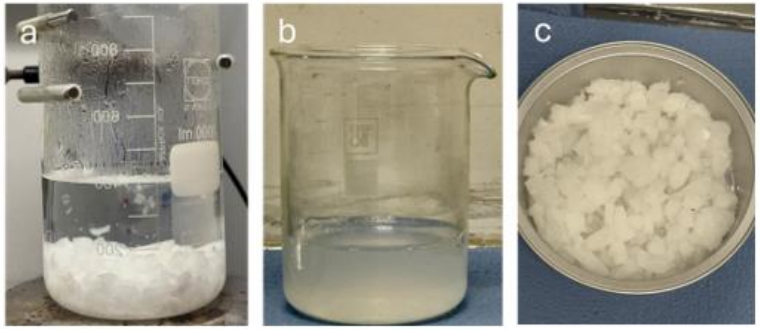


Fig. 8: (a) Recycled Recyclamine mixture containing solid particles before filtration, (b) Solution with precipitation, (c) Collected filtrate after filtration, used for further analysis.

Elium Route

✓ Complete dissolution in acetone

✓ ATH successfully recovered

⚠ Resin residue: 2.4–7.1% contamination

Recycleamine® Route

⚠ Swelling observed

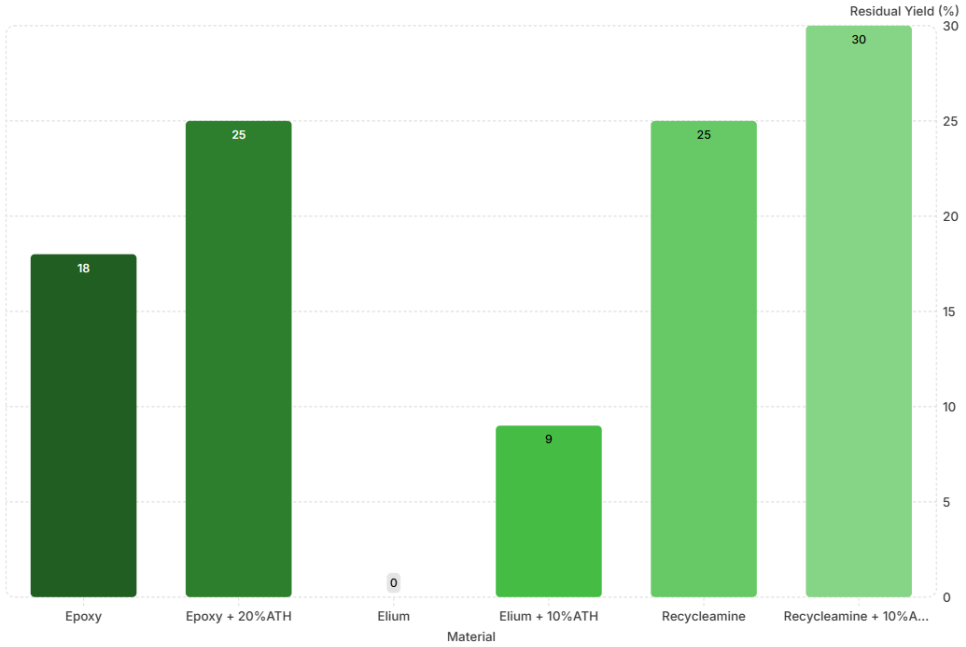
⚠ Partial dissolution only

⚠ Difficult particle separation

ⓘ Recycleamine recycling requires process optimization before deployment — a tractable engineering challenge given its performance advantages.

[1] Gebhardt et al., Journal of Plastics Technology, 2020, 16 (5), 180-210.

Impact of Recycling
State of the recovered additives



Recyclamine + 10%ATH — 30% Residual

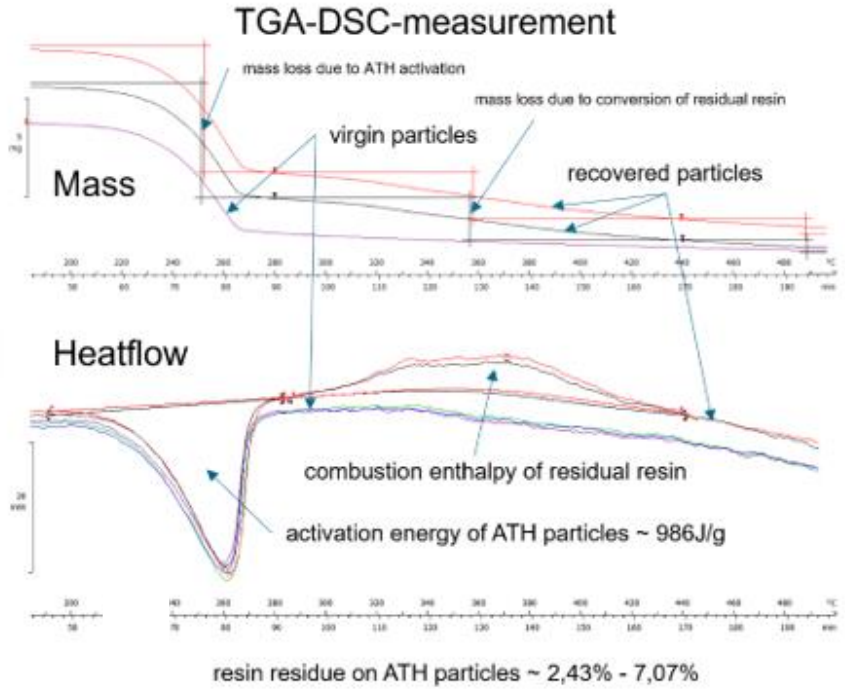
Synergistic effect of crosslinks and ATH conversion to Al_2O_3 forms a stable protective layer.

Elium + 10%ATH — 9% Residual

Methacrylate based structure yields minimal char despite ATH addition, representing a significant FST liability.

Why ‘Residual’ Matters

Higher residual formation creates a protective condensed-phase barrier, reducing heat feedback and volatile release — critical for FST compliance in aircraft cabins.



DSC-TGA based assessment of the recovered S-11 particulates showing a resin residue.

Recyclamine + ATH shows the strongest potential for FST-critical cabin monument applications.

Conclusion and Future Outlook
The way forward

Federal Ministry for Economic Affairs and Energy

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Key Conclusions

1 Recycleamine exhibited the highest thermal stability

Tg of 123°C with ATH — superior to all systems.

2 ATH improved stiffness and residual formation

+43% modulus in epoxy; 30% residual yield in Recycleamine.

3 Recycleamine + ATH: best overall performance

Leading thermal, mechanical, and fire resistance metrics.

4 ATH recovery from Elium is feasible

2.4–7.1% resin contamination requires further refinement.

Future Outlook

Optimize ATH Recovery

Improve filtration setup and reduce resin residue.

Optical Microscopy

Analyze agglomeration of ATH particles

Tensile and Flexural Testing

Tensile tests will be performed on the flame retardant EP360 laminates to evaluate their strength, stiffness and load bearing performance

Reuse Evaluation

Assess recovered ATH performance in secondary composites.

Recycleamine + ATH is the most promising sustainable alternative for aircraft cabin monuments — pending recycling process optimization.

Acknowledgement

- BMWE for funding (20K2201D) under LuFo VI scheme.

- Project partners: TU Clausthal, Frauhofer IFAM, Fraunhofer LBF, SAFRAN Cabins Germany GmbH, INVENT GmbH.

- Co-Authors.

Imprint

Topic:	**ECCM22: CirKle Special Session** Sustainable Composites for Cabin Monuments – Recycling of Resins with tailored FST Properties
Date:	2026-06-23
Author:	Souvik Chakraborty
Institute:	Institute of Lightweight Systems
Image sources:	All images “DLR (CC BY-NC-ND 3.0)” unless otherwise stated