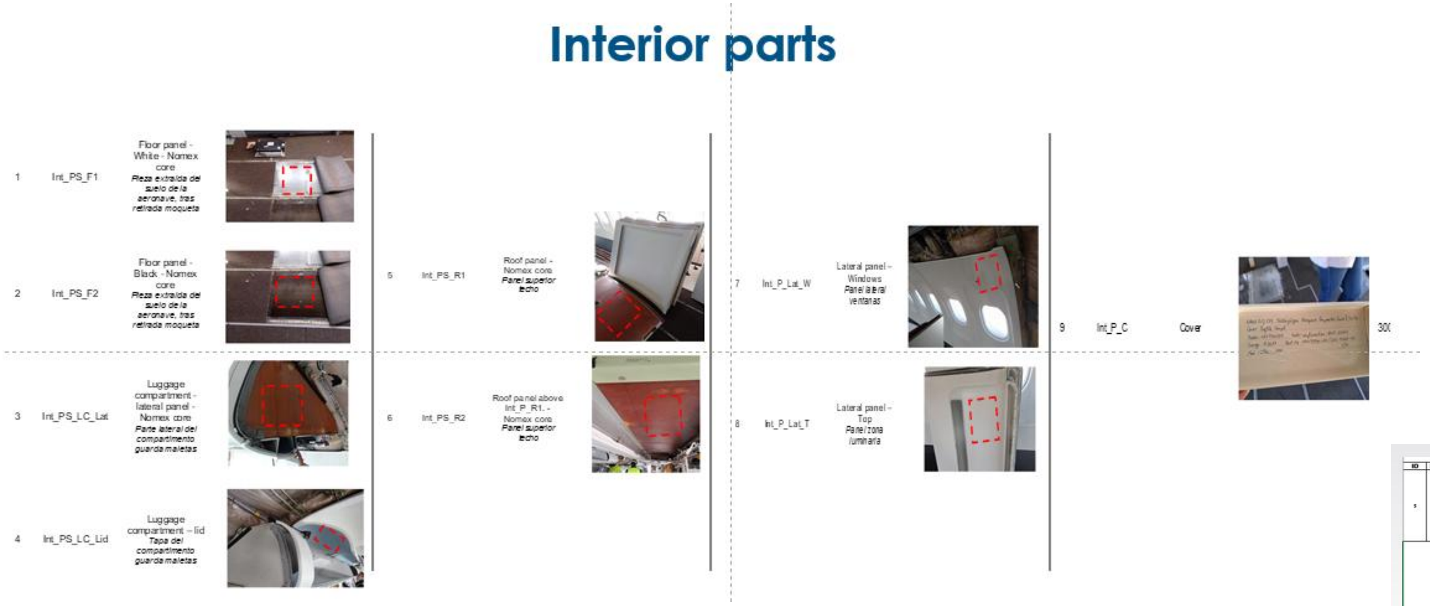
AIRECOMP PROJECT

CABIN INTERIORS RECYCLING

07 June 2025 **Workshop 15: AFRA R&D Aircraft Interiors Recycling**

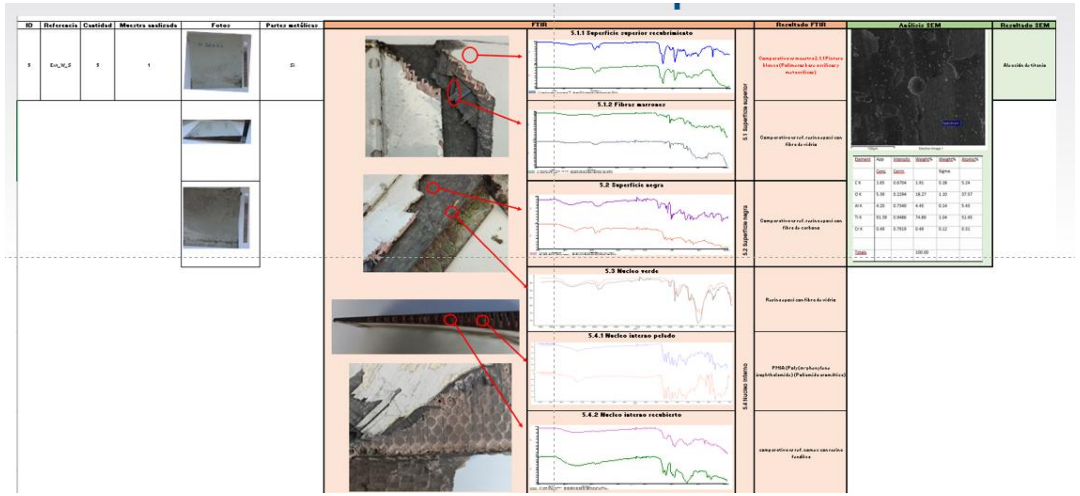
Nº EXP: EC-06-2022

02.-Material identificación



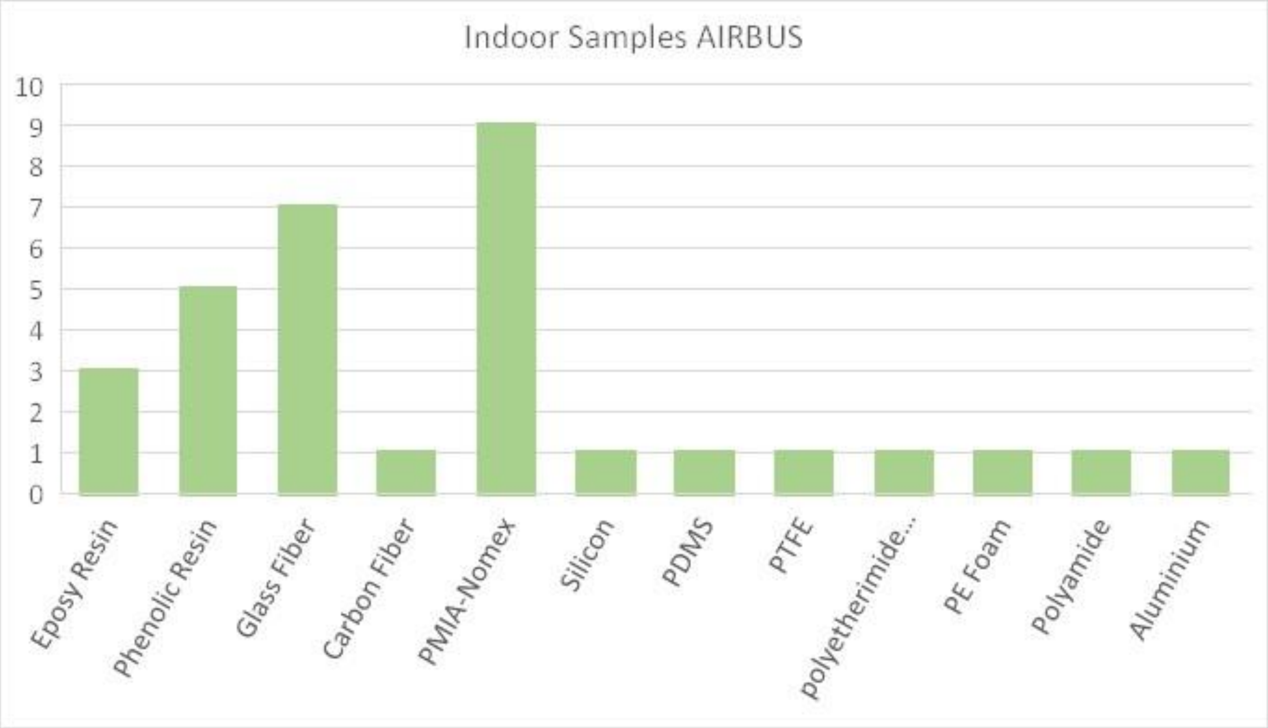
Boeing B737
Airbus A321

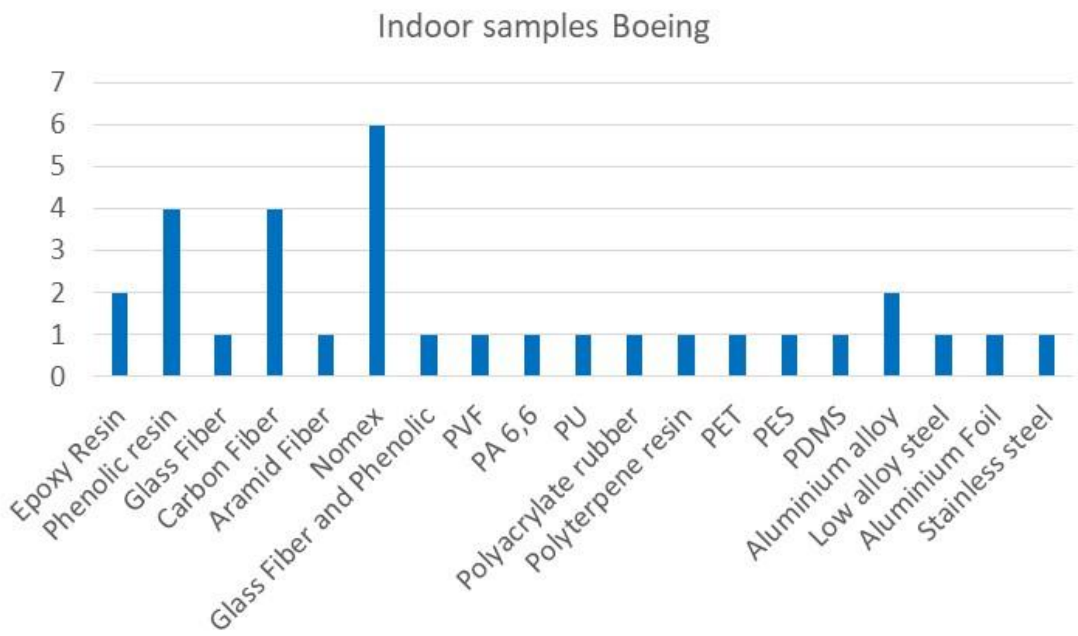
FTIR analysis of materials components



02.-Material identificación Airbus/ Boeing

Number of times the material appears in the analyzed samples.



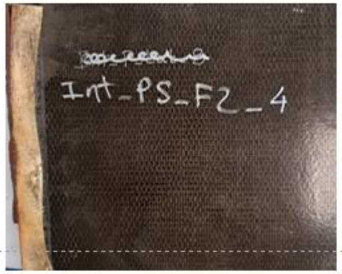


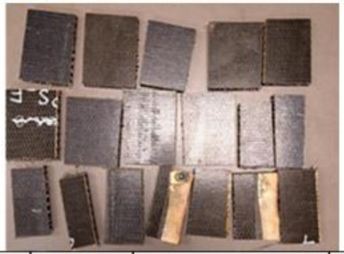
Different planes, different material

MECHANICAL RECYCLING

03.-Mechanical recycling

- Maximum grinding to powder/dust: Blending with recycled PP matrix, use of compatibilizers





Int_PS_F2	Epoxy resin	Carbon fiber	Glass fiber	PMIA-Nomex	PTFE

Ø = 6 mm

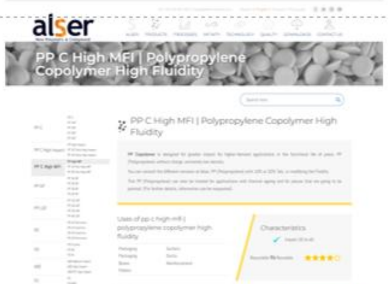
Ø = 2 mm

Ø = 0.25 mm

Without sorting materials, grinding of composites and valorization as fillers for thermoplastic matrix: PP & PLA

Blending	%		
	Recycled Polypropilene	"Aircraft dust"	Compatibilizer [6%] Polypropylene-graft-maleic anhydride
M1	100	0	No
M2	95	5	No
M3	90	10	No
M4	85	15	No
M5	70	30	No
M6	95	5	Yes
M7	90	10	Yes
M8	85	15	Yes
M9	70	30	Yes

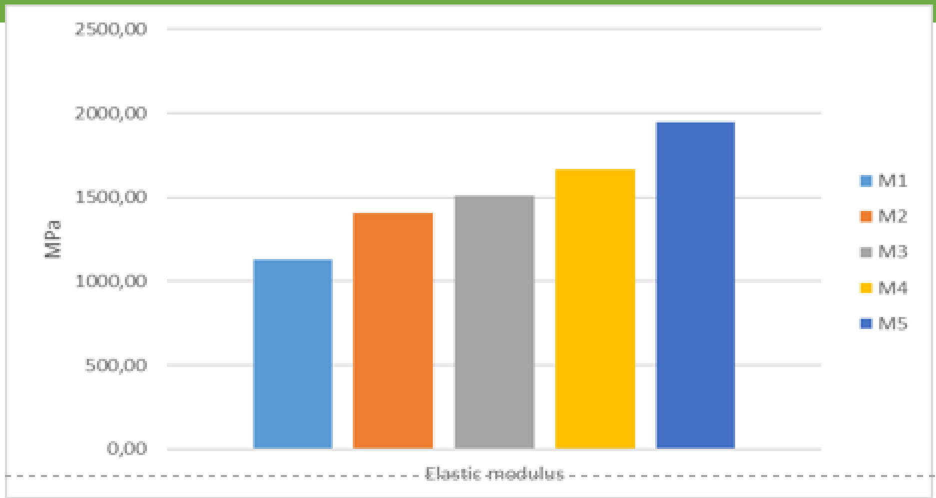
PP (polypropylene)

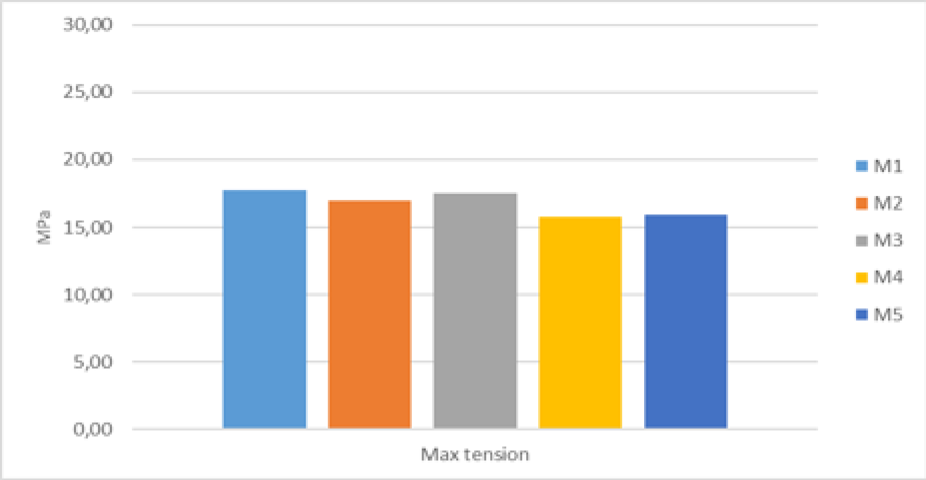


03.- Mechanical recycling -rPP

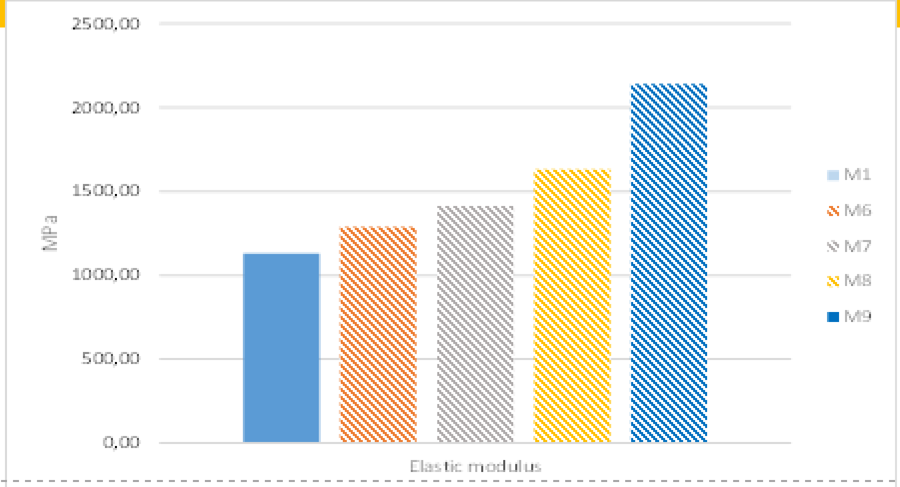
Mechanical recycling – Tensile test

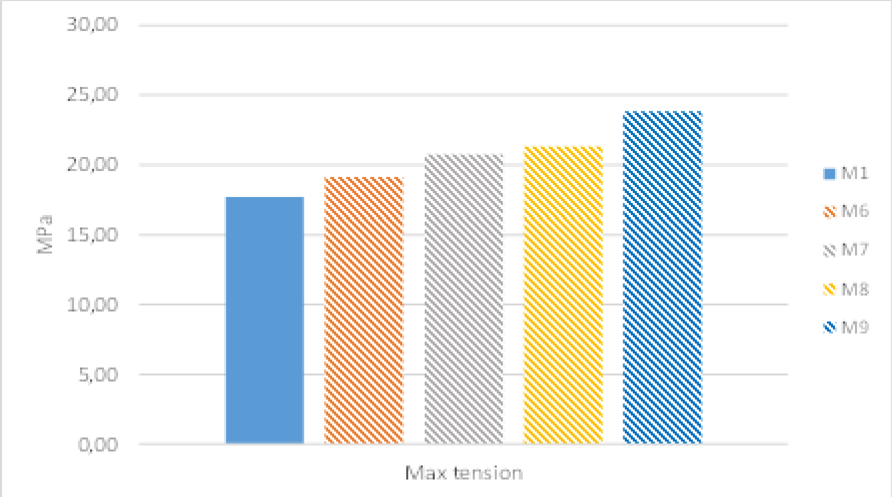
Without compatibilizer





With compatibilizer

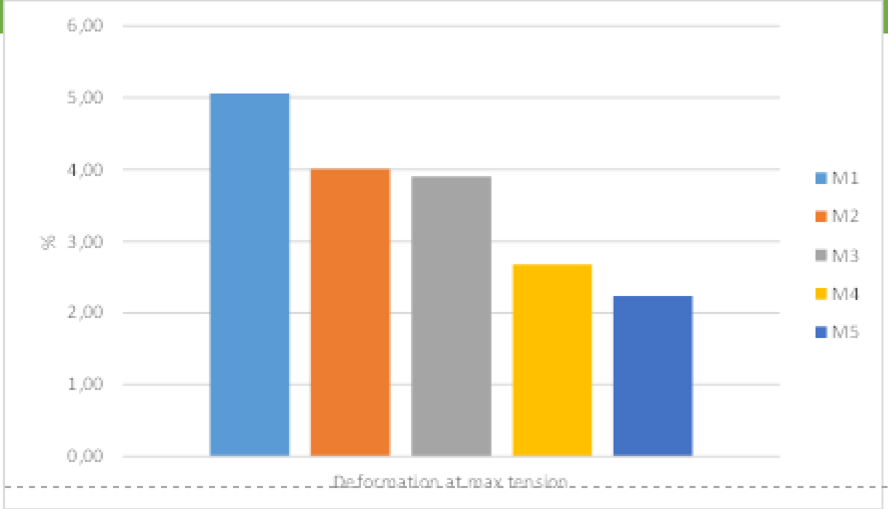


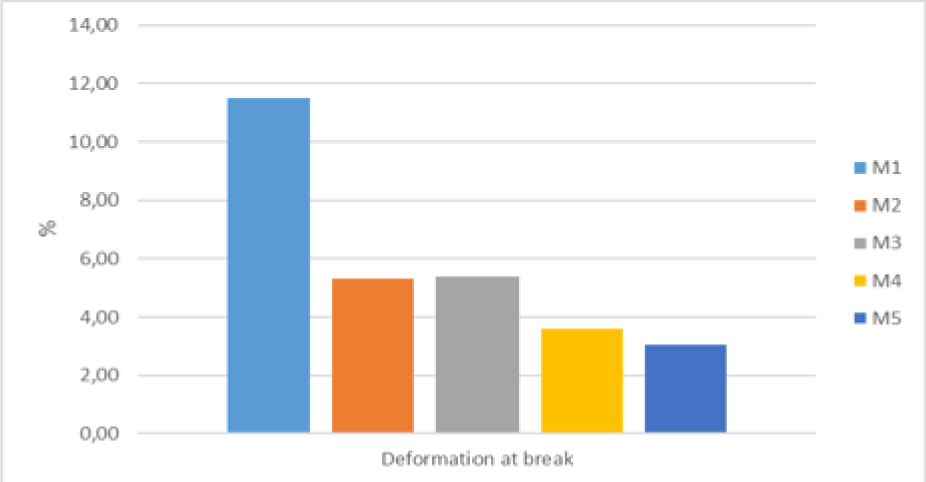


03.- Mechanical recycling -rPP

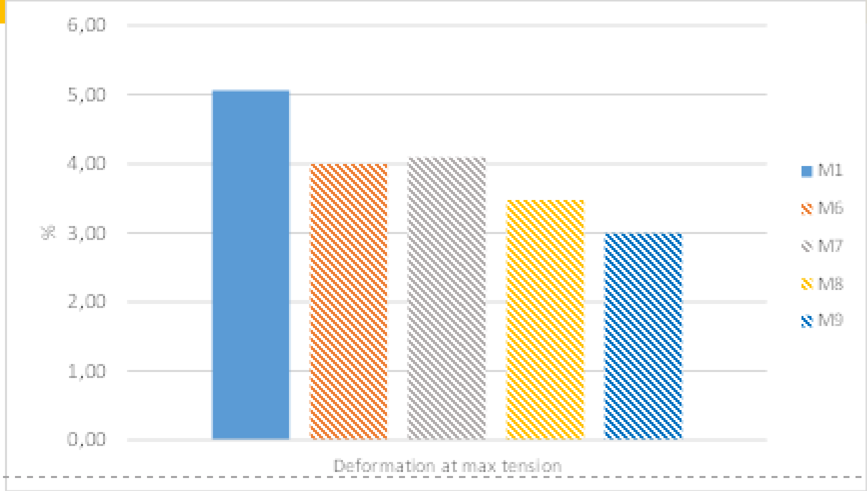
Mechanical recycling - Tensile test

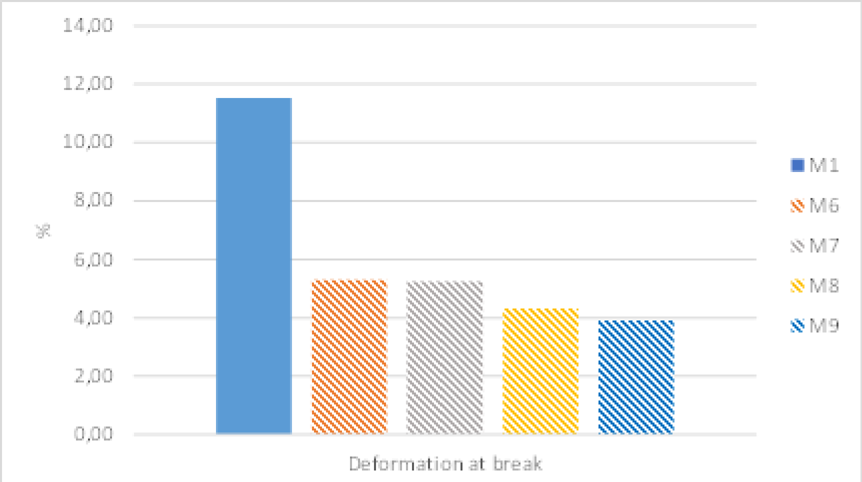
Without compatibilizer





With compatibilizer

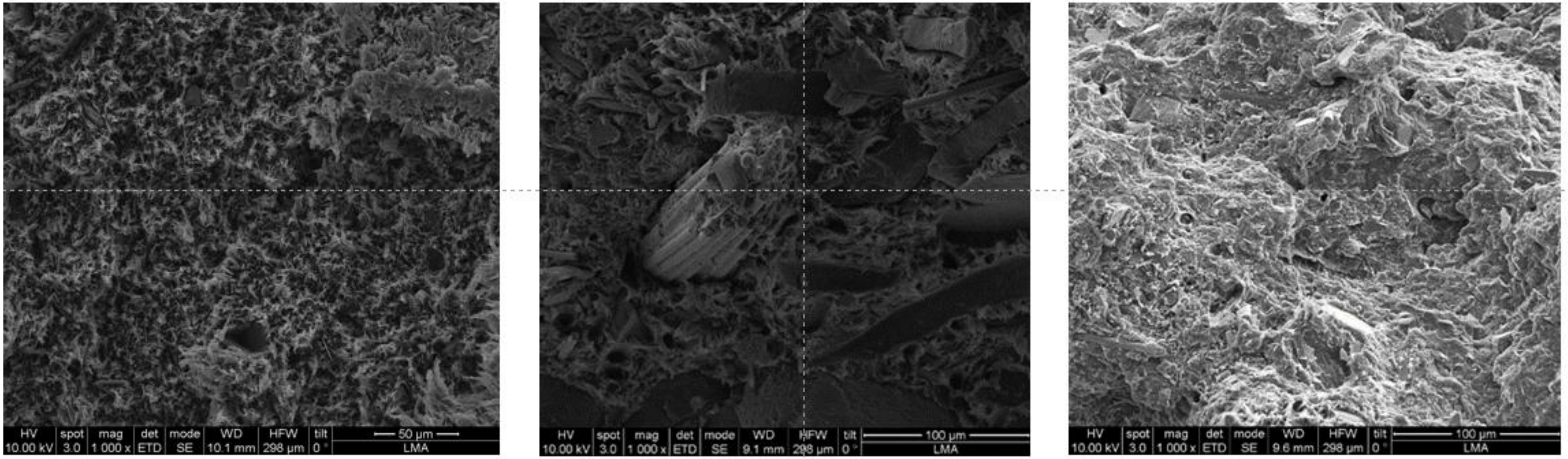




03.- Mechanical recycling -rPP

Mechanical recycling - SEM

Control | Without compatibilizer | With compatibilizer



CHEMICAL RECYCLING

1. Bibliographic review

Selected method for chemical recycling

Advantages

- ✓ Room temperature
- ✓ Atmospheric pressure
- ✓ Environmentally friendly recycling method: operating conditions at room temperature and atmospheric pressure combined with the recyclability of formic acid → contribute to the sustainability of the whole approach.
- ✓ Successfully used in large carbon fiber reinforced polymer composite panels.
- ✓ Effectiveness demonstrated through a proof-of-concept manufacturing of a new composite part based on recycled fibers.
- ✓ Preserves the woven fiber architecture of the waste (the recycled fabric layers): by preserving the fiber architecture, they could be reused directly after minimal further processing to make fiber composites.

https://doi.org/10.1038/s41598-022-09932-0

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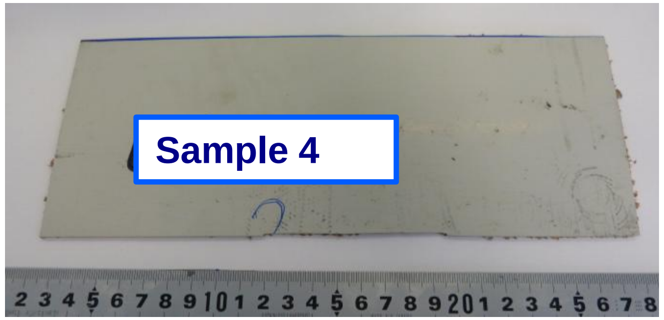
OPEN

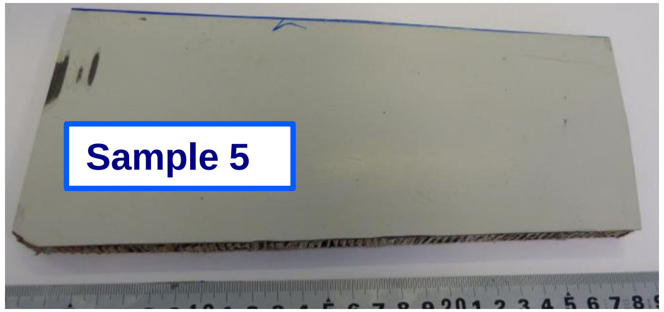
High performance recycled CFRP composites based on reused carbon fabrics through sustainable mild solvolysis route

W. Ballout[1✉], N. Sallem-Idrissi[1], M. Sclavons[1], C. Doneux[2], C. Bailly[1], T. Pardoen[2] & P. Van Velthem[1]

3. Implementation of the procedure in the laboratory

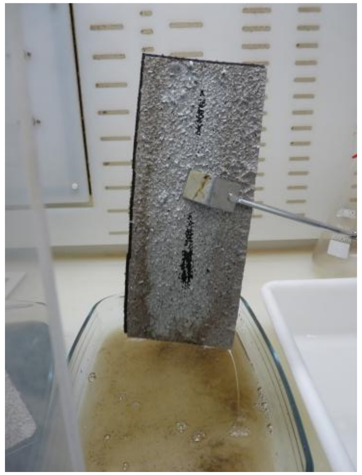
3.1 Real lab-scale samples





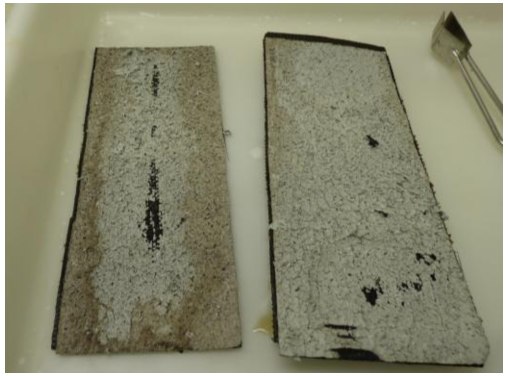
Sample 4:
Sample2 from Boeing 737
Topcoat with coreless paint
Approximate size: 25 x 10 cm

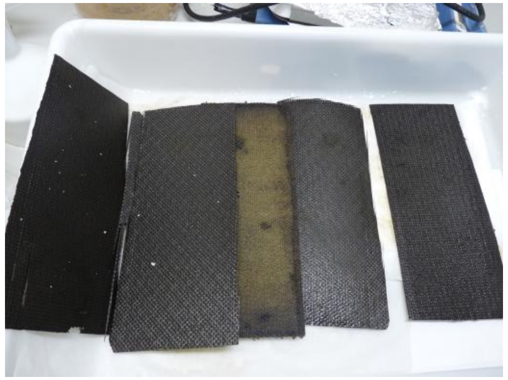
Sample 5:
Sample 2 from Boeing 737
Topcoat with core paint
Approximate size: 25 x 10 cm



Distilled water wash

Vacuum drying

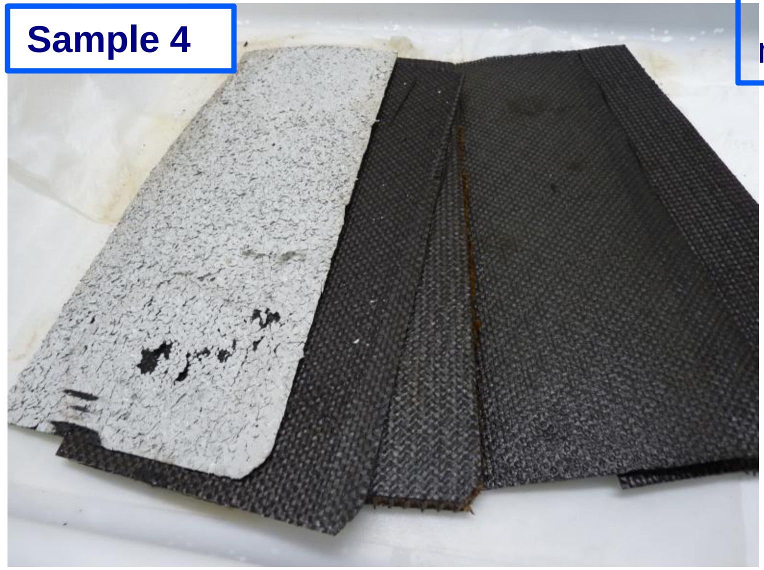




Drying to ambient conditions

3.3 Results

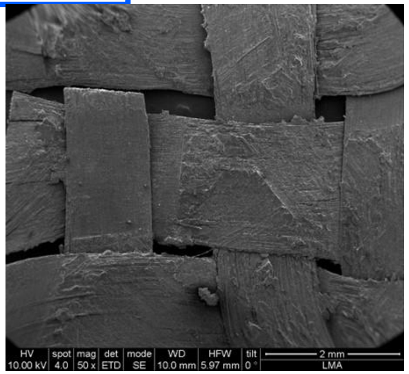
Sample 4

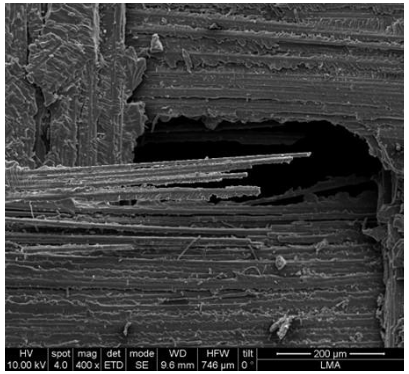


Sample 4

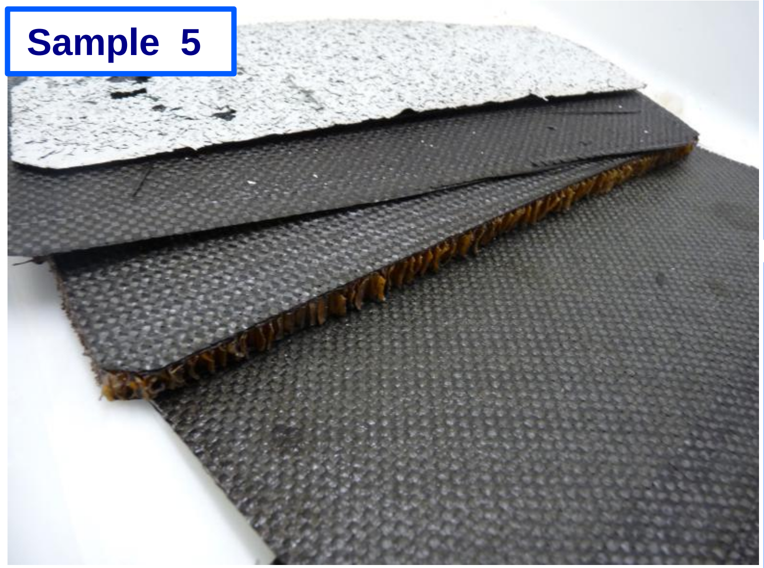
The different layers of carbon fiber fabric have been mostly separated from each other.

Observation by SEM
The weave of the fabric is visible.
The fibers show traces of resin





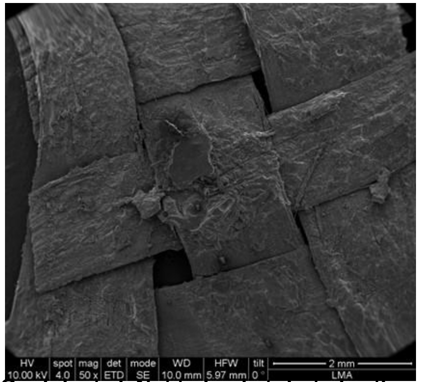
Sample 5

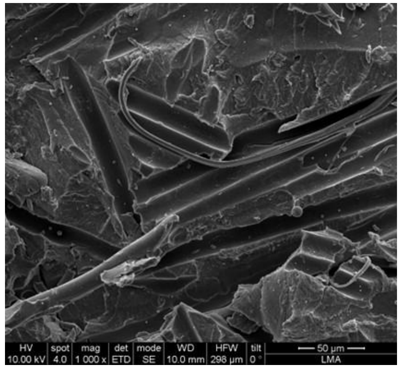


Sample 5

The different layers of carbon fiber fabric have been separated except for the layers bonded to the aramid core.

Observation by SEM
The weave of the fabric is visible.
The fibers show traces of resin
The aramid core hinders the process: it increases the amount of formic acid needed and slows down the drying process.
The CF layers adjacent to the core do not separate.

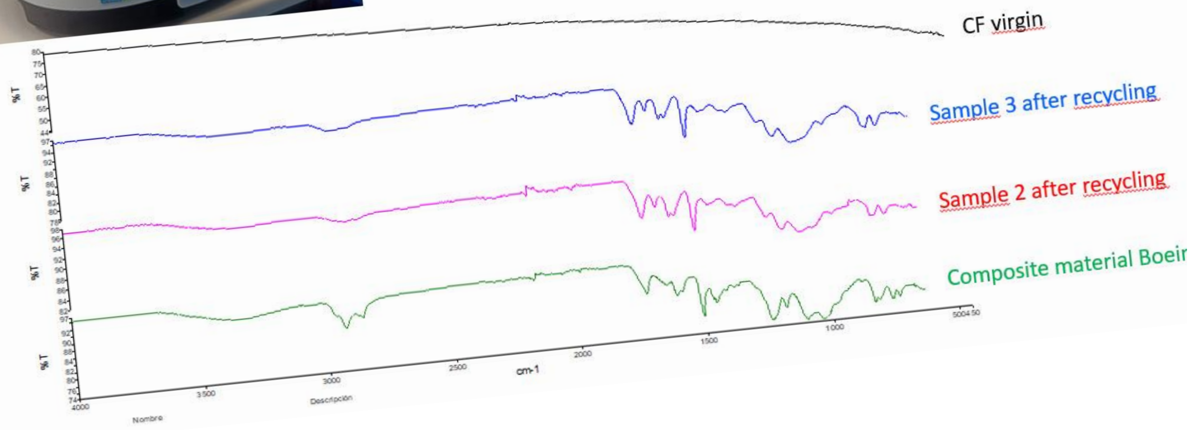




3.3 Results: FTIR and TGA analysis

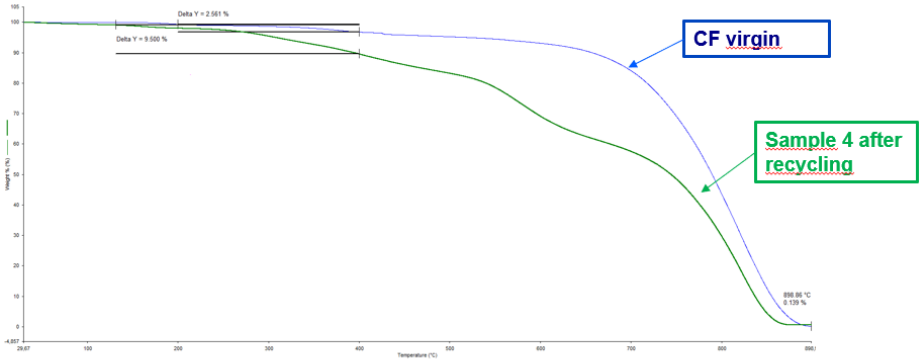
3.3 Results: Spectroscopy FTIR

Samples after formic acid exhibit FTIR spectra similar to the samples before. Confirms the presence of residual epoxy resin.



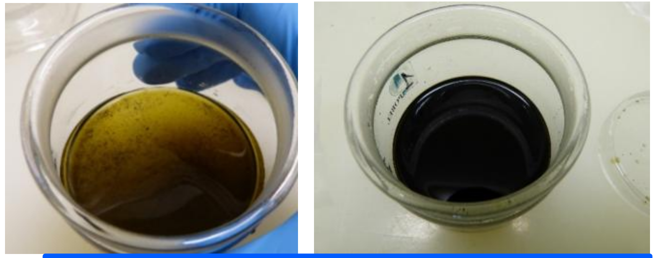
Physical-chemical analysis to study resin content

3.3 Results: Thermogravimetric analysis (TGA)



Results TGA:
2.6% by weight of sizing in virgin CF
Epoxy resin remaining in fibres: about 7% by weight

Results TGA bibliography
2% by weight of sizing in virgin CF
Epoxy resin remaining in the fibres: about 10% by weight



1st use | 4th reuse

The acid volume decreased and its appearance turned blackish, likely due to decomposition by-products

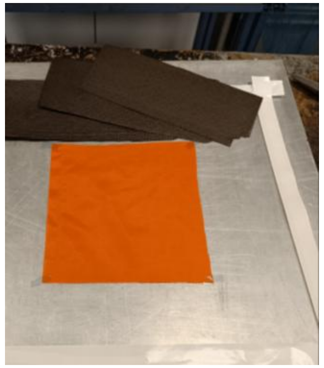
Process optimization: Reuse of acid formic

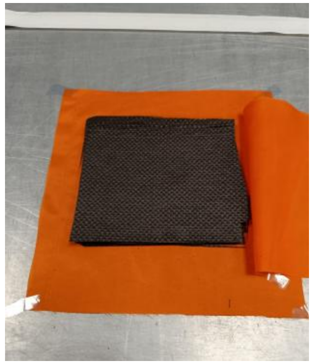
4. Composite fabrication with recycled CF

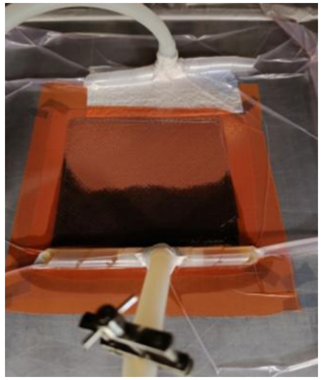
LAMINATE MANUFACTURING:

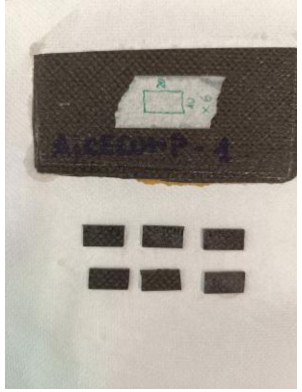
1. Some plies are recovered from a composite airplane part by Formic acid digestion
2. Since the part composition is unknown, the number of plies is unknown too

   (Important for future actions: a well knowledge of each part)
3. 3 plies 200x100 mm roughly were recovered
4. These plies were cut into 6 plies of 100x100mm so as to prepare a rFC epoxy laminate
5. Process:
   1. LRI (Liquid Resin Infusion) vacuum assisted with RTM6 epoxy resin (suitable for aeronautics parts)
   2. Curing cycle: 2h @ 180ºC (1ºC/min ramps up and down)
6. Testing









Future Work to be defined – Summary of Key Research Areas

Recovery of Painted Composite Parts (No Core)

- Optimize processing conditions (shorter digestion times: 16 h, 8 h…).
- Reduce formic acid volume in trials.
- Improve methods for removing paint and core residue to fully recover all 3 CF layers.
- Evaluate alternative rinsing and drying techniques (e.g., ambient conditions vs. vacuum).
- Explore pretreatment strategies to enhance diffusion rates.

Recovery of Other Composite Configurations

- Assess the influence of carbon fiber (CF) layer count on key parameters:
  - Digestion time
  - Diffusion time
  - Formic acid volume
- Investigate reuse/recycling options for Nomex core materials.

Improvement of Final Composite Properties

- Explore methods to enhance interfacial reinforcement of CF (literature review)
- Manufacture composites using larger CF fragments to allow full characterization.
- Use RTM and infusion techniques with the same resin as the original composite.
- Assess laminate quality: fiber/resin/void content.
- Work with larger sample sizes to enable comprehensive testing.
- Conduct full mechanical characterization: ILSS, Iosipescu, Shear, Compression / Compare virgin vs. recycled composites
- If no virgin reference material is available, produce it in-house and simulate aging.
- Consider different fabric types: unidirectional and multiaxial.

Industrial Process Scaling

- Analyze potential applications of recovered aerospace fabrics based on final mechanical properties.
- Study size distribution and quantity of recovered fabrics.
- Scale up chemical process: equipment, reagents, and timing.
- Perform cost analysis.

AIR
AVIATION INTERNATIONAL RECYCLING

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