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Towards more sustainable matrices for composites at sea

Thermoplastic composites at Ifremer

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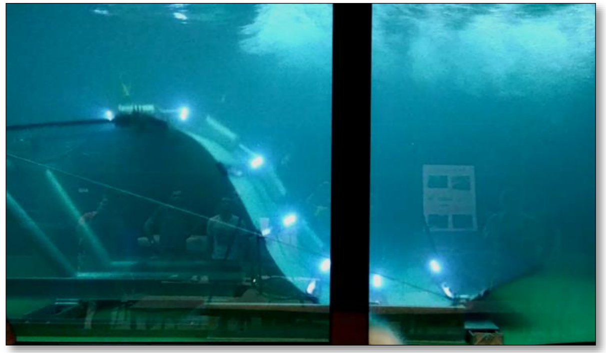
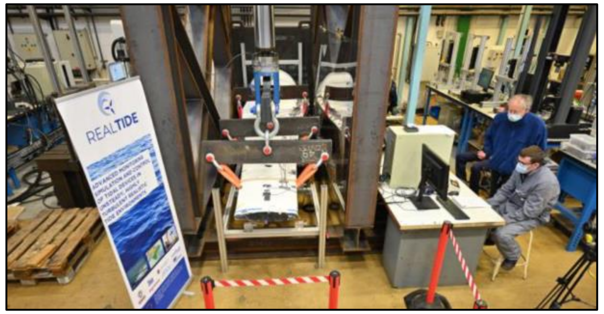
Introduction – Composites at sea

Several applications

Marine Renewable Energies

Racing boats

Marine ships

Deep-sea Exploration

Content

1. Infusible thermoplastics
2. « Biodegradable » thermoplastics
3. Semi-cristalline thermoplastics

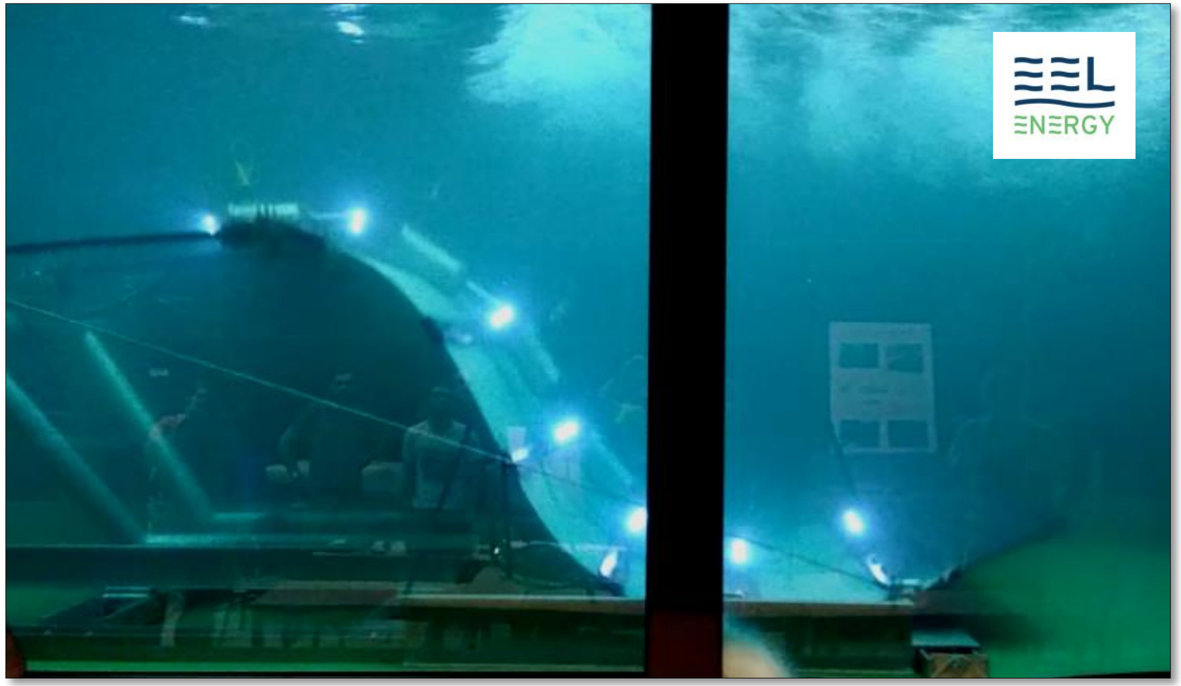
1 – Infusible Thermoplastics

ELIUM®

1 – Infusible Thermoplastics

Context - Membrane that ondulates with ocean currents to produce energy

First prototype was made of glass/Epoxy



Coupling between sea water aging and flexural fatigue

Aim: Is it possible to replace the epoxy resin by the Elium resin ?

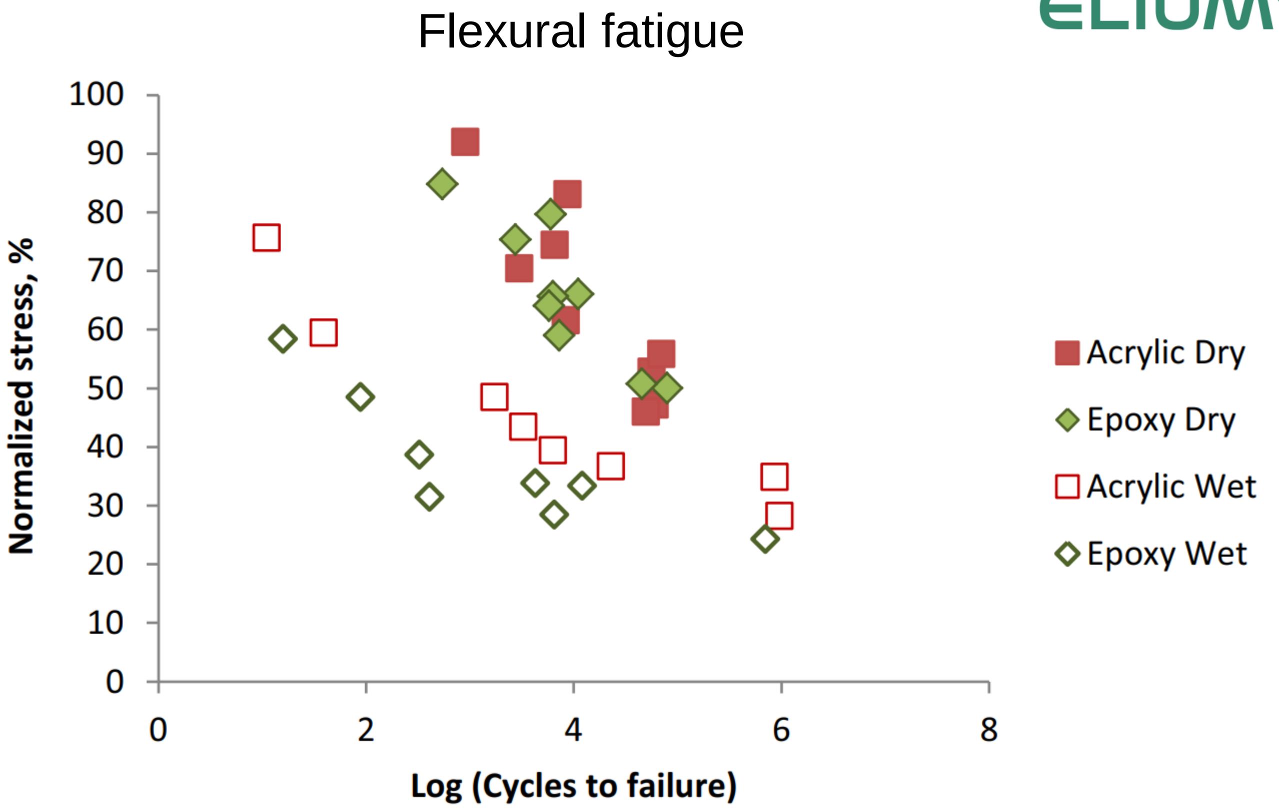
ELIUM®

Ifremer

1 – Infusible Thermoplastics

Mechanical properties after aging in sea water

ELIUM®



Comparable/Better durability in sea water that common infusible epoxy resins

End-of-life ?

2 – Biodegradable Thermoplastics

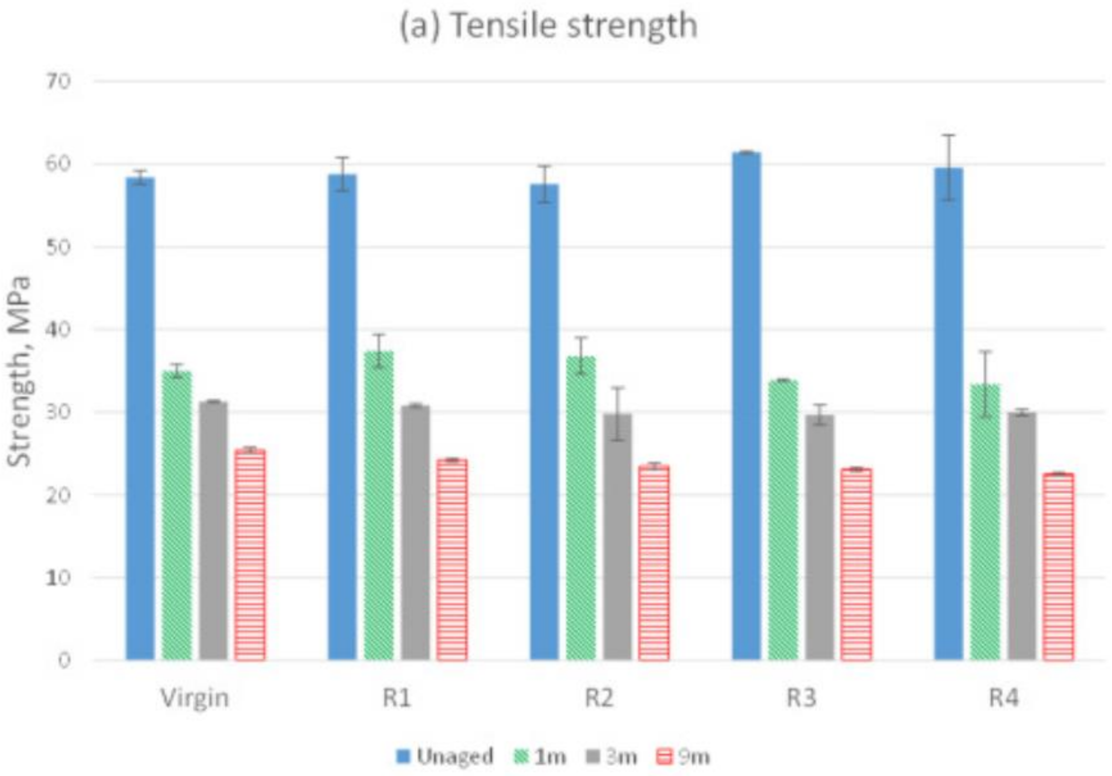
- Flax/PLA
- PBSAT

2 – Biodegradable Thermoplastics

Aim: To try and produce crab pots made of flax/PLA (short fibres)

Recycled 4 times

Shredding, compounding, injection moulding



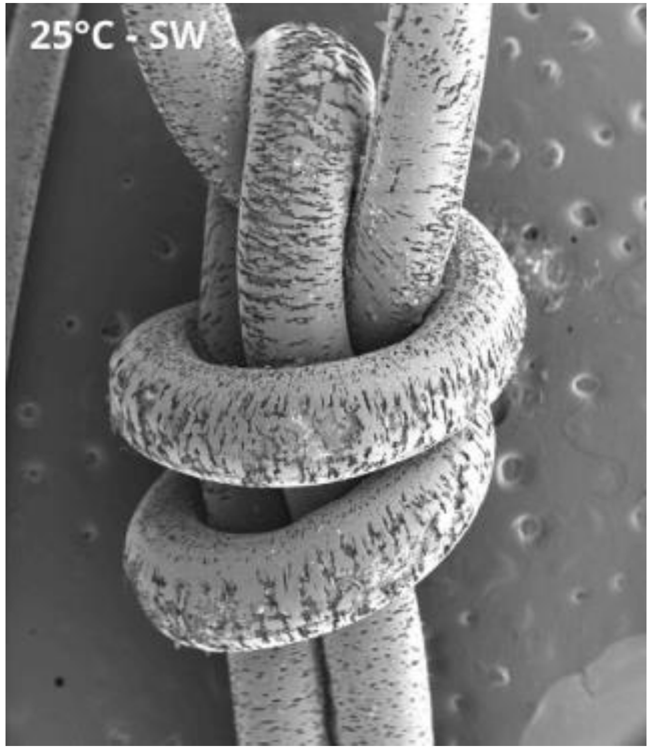
Appears possible to recycle

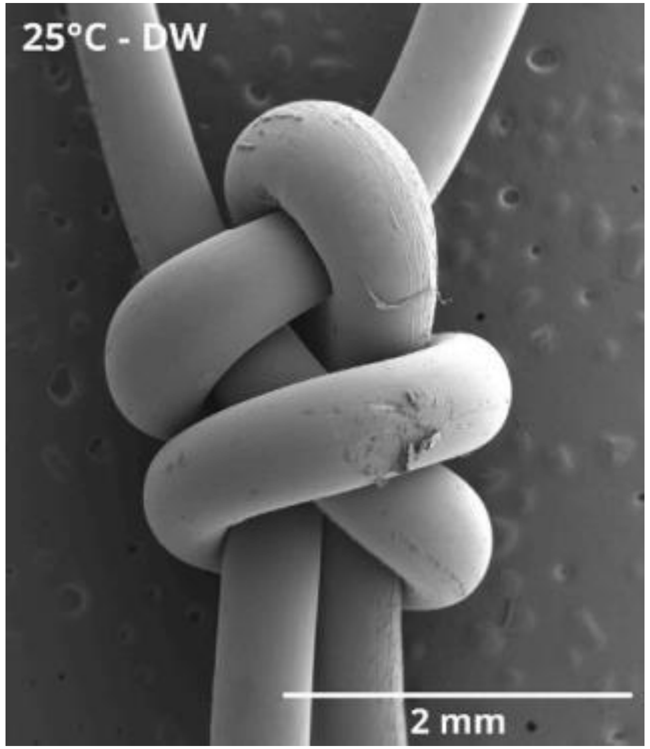
Low performance and poor durability

2 – Biodegradable Thermoplastics

Not a composite study – PBSAT monofilament for gillnets

Aging at the same temperature (25°C) but different medium





Loss in Strength 50% after 240 days

Degrades due to microorganisms in sea water – Mineralized ?

Poor durability in sea water

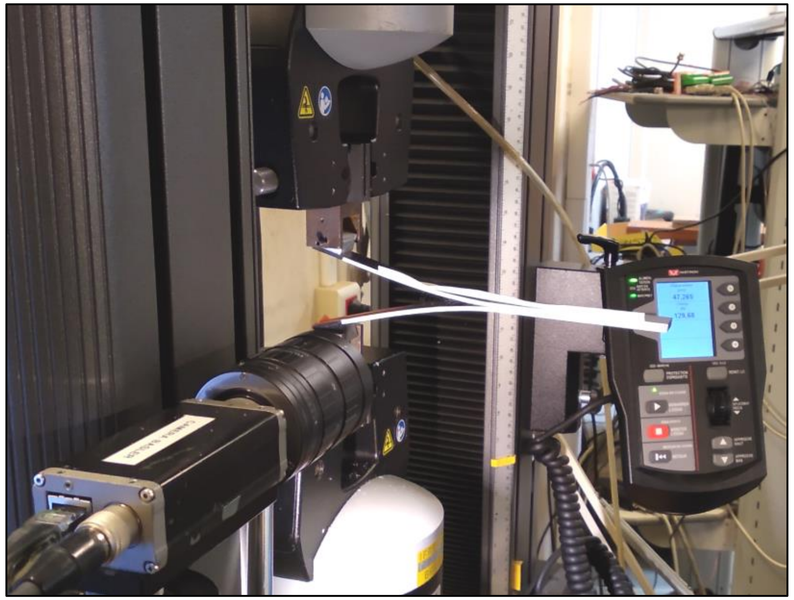
3 – Semi-Cristalline Thermoplastics

- C/PA6

3 – Semi-Cristalline Thermoplastics

Case of C/Polyamide 6 – Unidirectional [0] DCB specimens – 5 mm thick

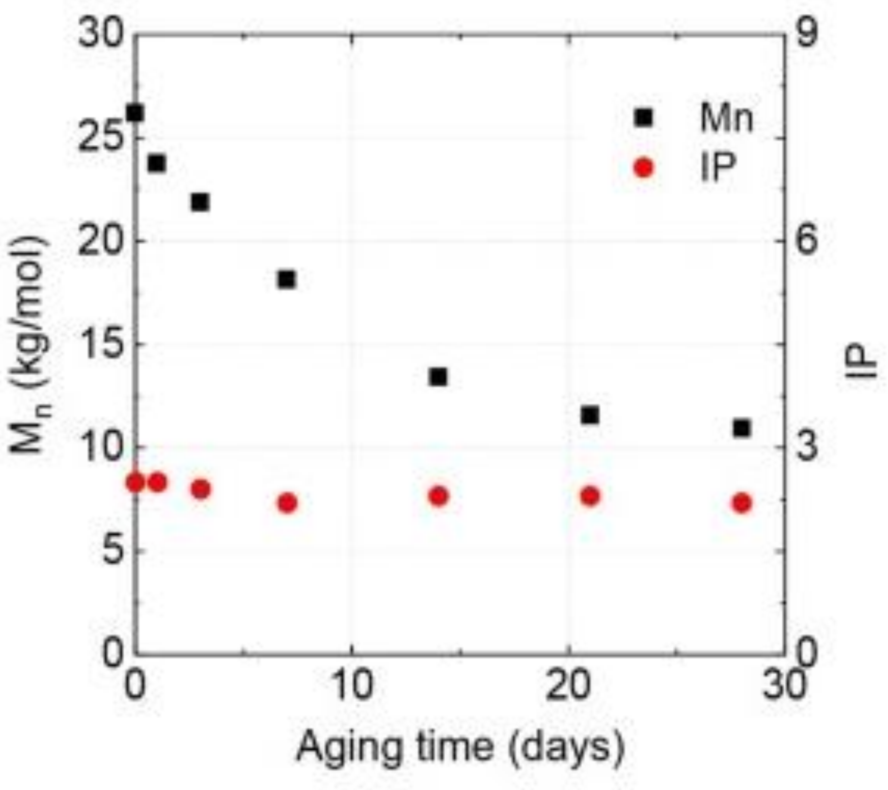
Aim of the study: Is it possible to repair thermoplastic composites after extensive degradation ?

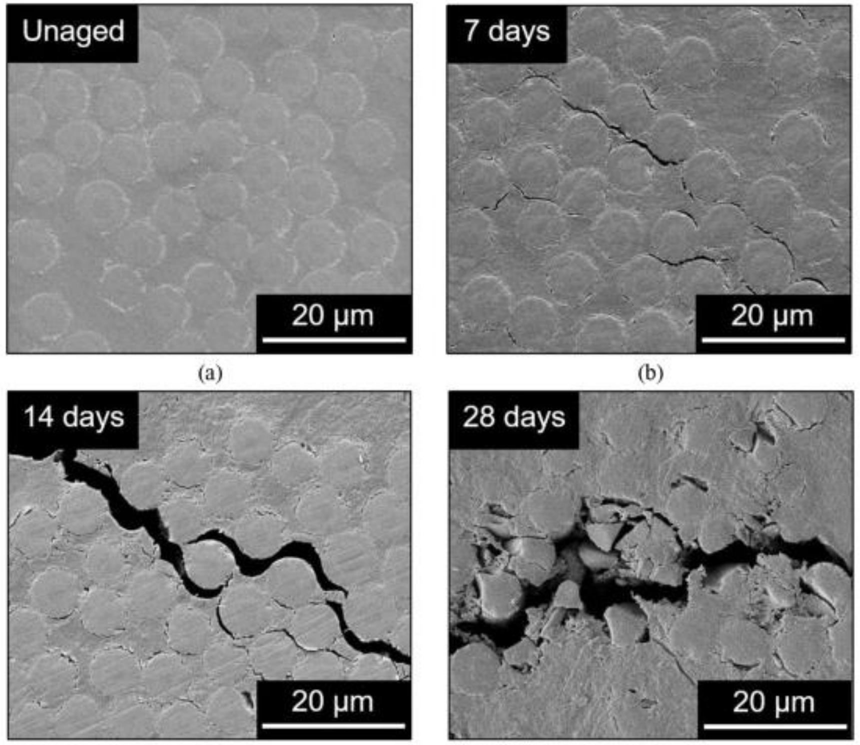


Expensive compared to the properties reachable with carbon/epoxy

3 – Semi-Cristalline Thermoplastics

Specimens aged at 120°C in deionised water – Consequences on microstructure



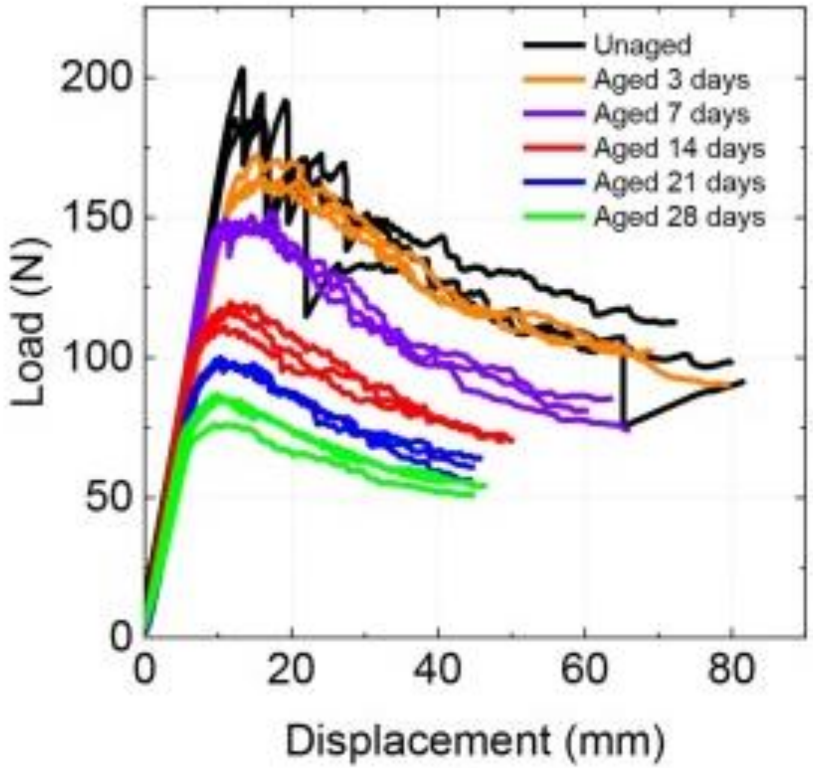


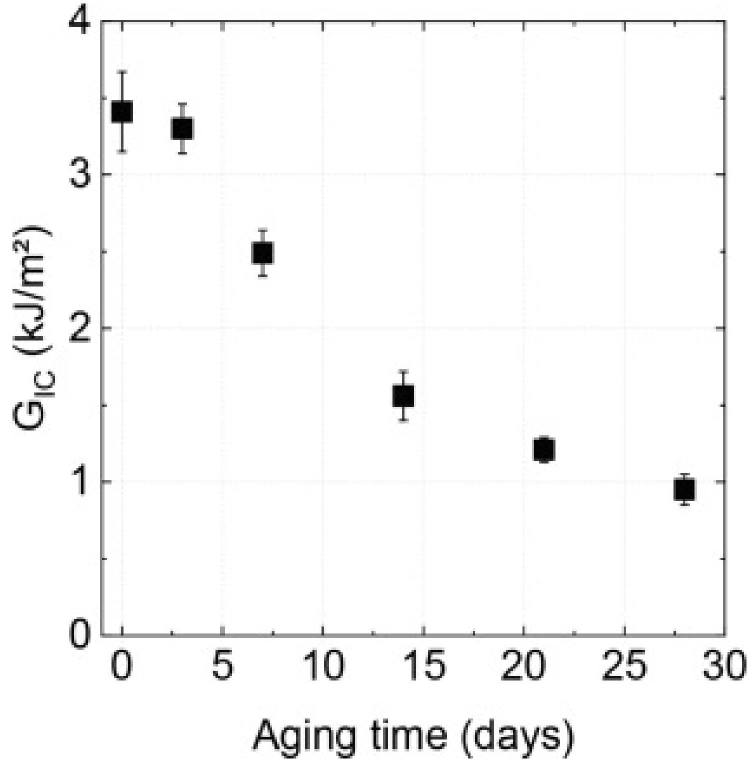
(a) (b) (c) (d)

Hydrolysis leads to chain scissions

3 – Semi-Cristalline Thermoplastics

Specimens aged at 120°C in deionised water – Consequences on mechanical properties

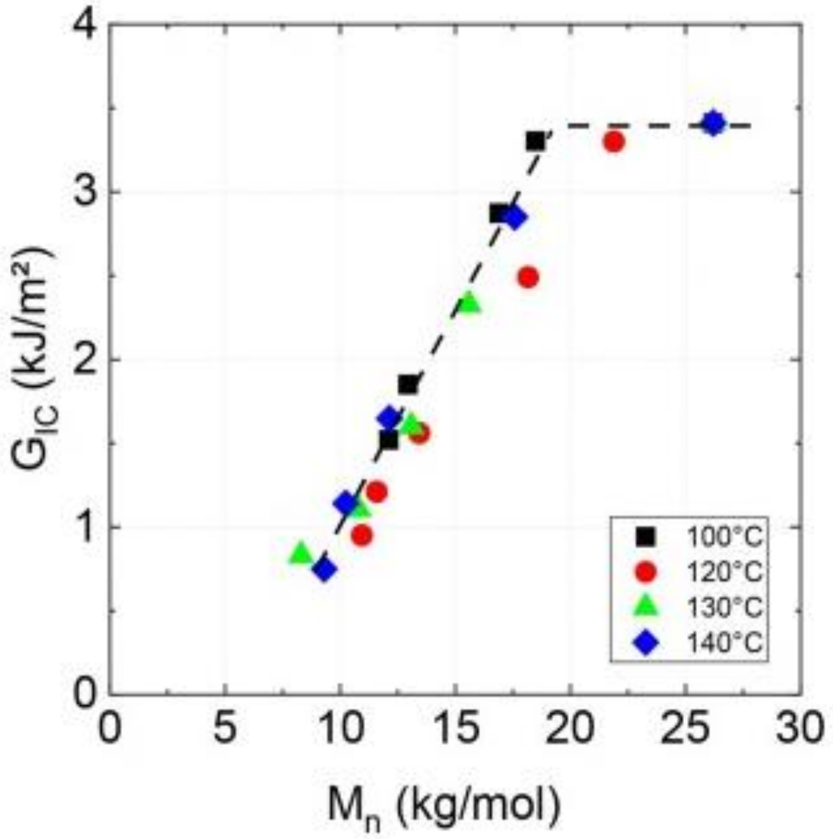


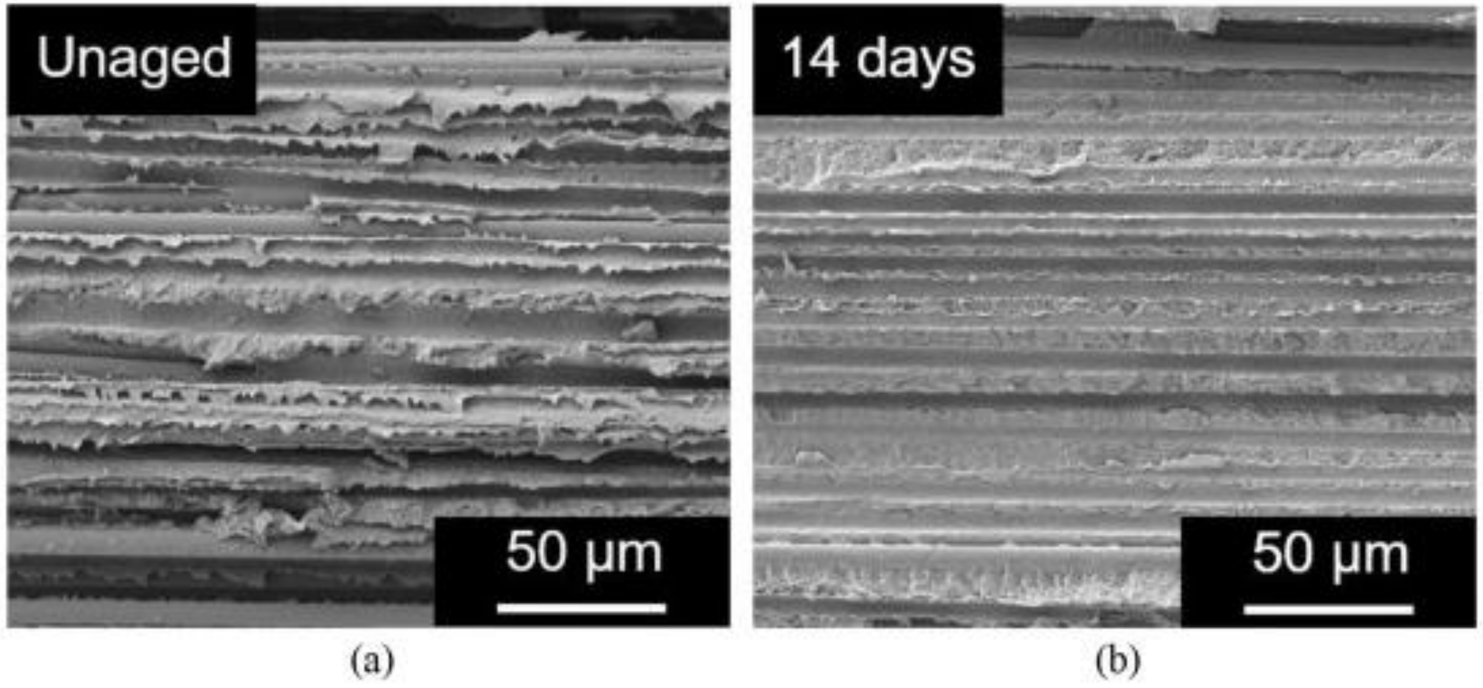


Loss in G_{IC} induced by aging

3 – Semi-Cristalline Thermoplastics

Specimens aged at 120°C in deionised water – Consequences on mechanical properties



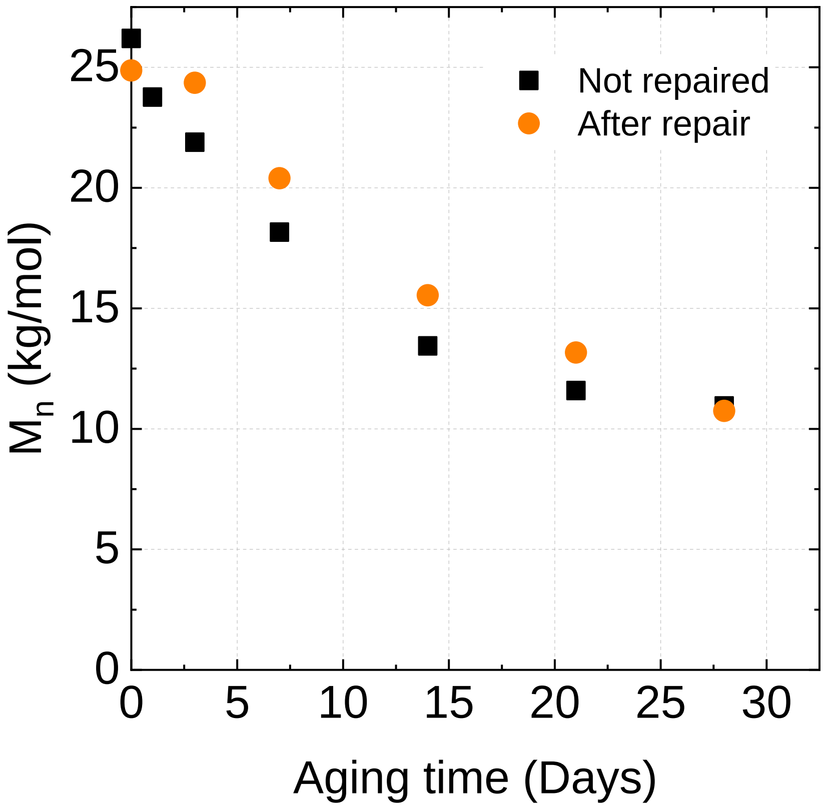


Ductile/brittle transition

Can we repair these specimens ?

3 – Semi-Cristalline Thermoplastics

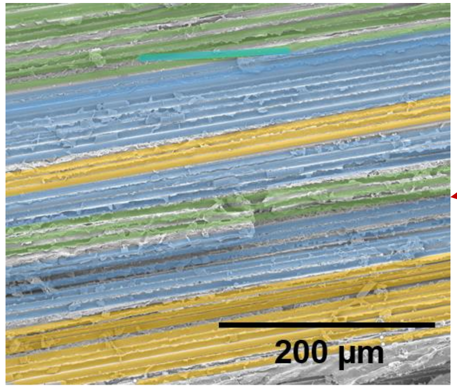
Repair using the same manufacturing cycle

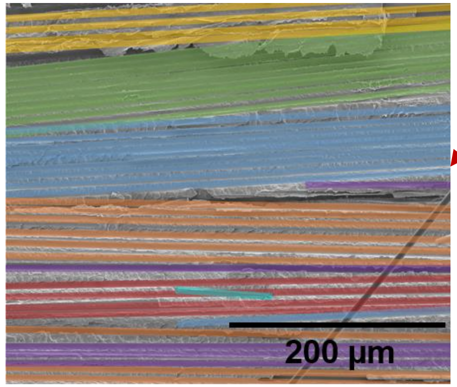


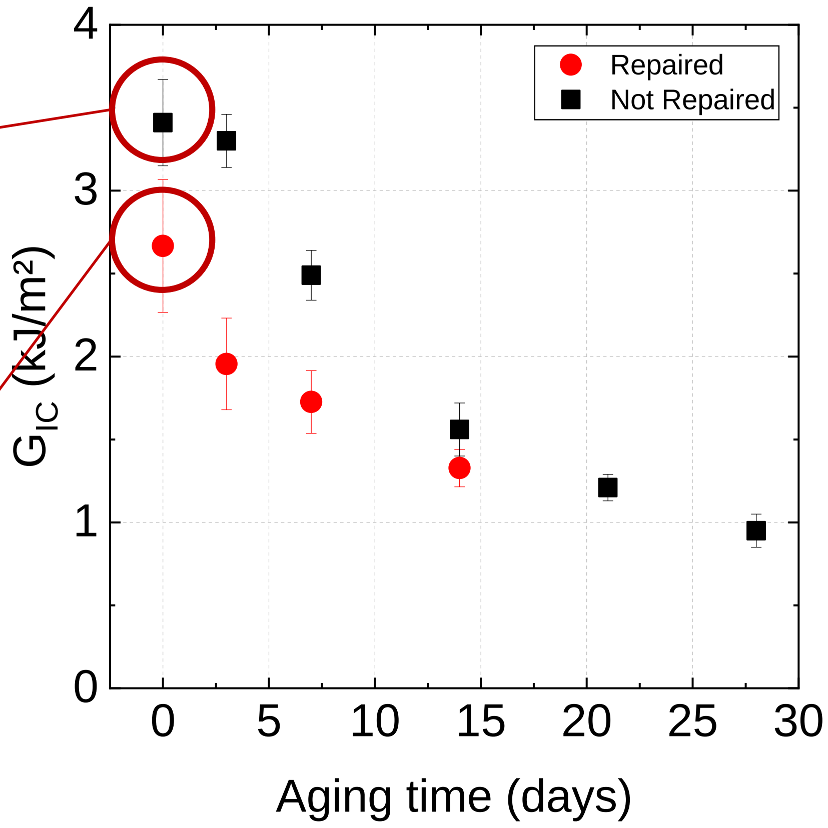
Increase in M_n, Increase in G_{IC} ?

3 – Semi-Cristalline Thermoplastics

G_{IC} after repair





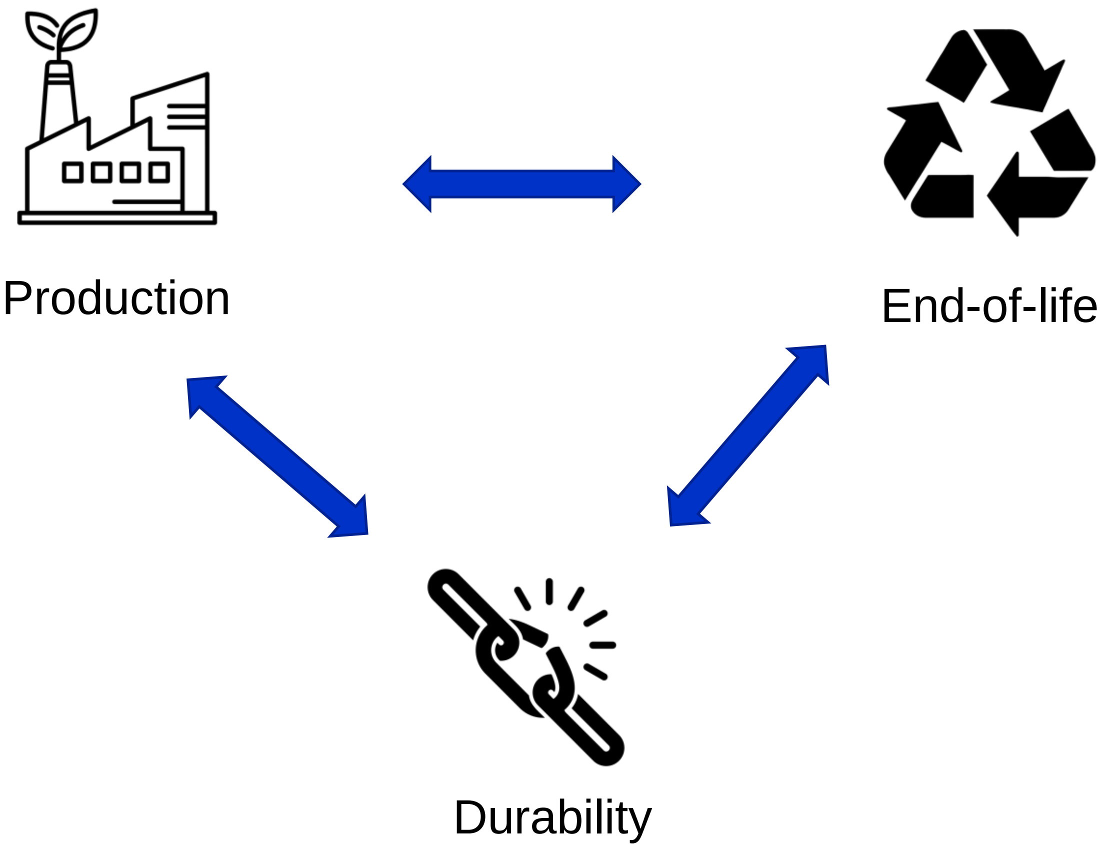


G_{IC} properties after repair not fully recovered

Additional work needed

Conclusions

For every case – A compromise is to be found



No matrix that easily solves all these issues but many promising ones

Thank you for your attention