Effect of Thermal Degradation of Glass Fibre Sizing on Interfacial Adhesion

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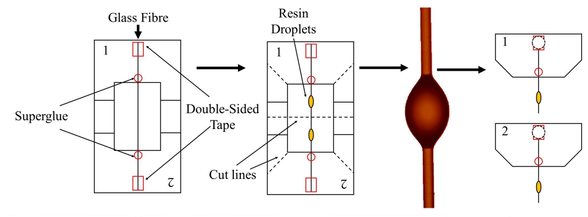
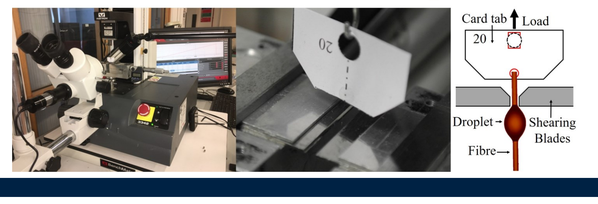
Background

- Global wind turbine waste > 43 million tonnes by 2050.
- Conventional waste disposal methods already banned in several European countries. Solutions needed urgently!
- Fibre properties reduced during composite recycling.
- Solutions need understanding of sizing decomposition.
- Characterisation of relationship between elevated temperature processing and interfacial adhesion.



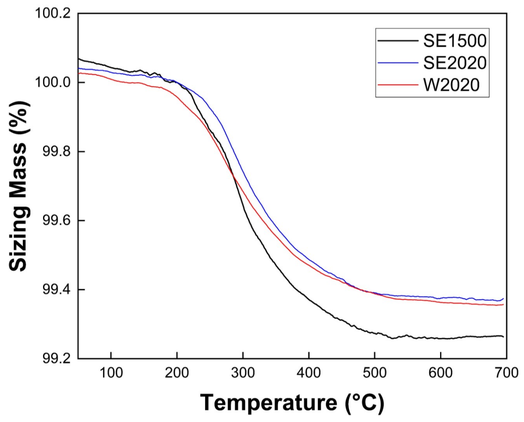


Methods

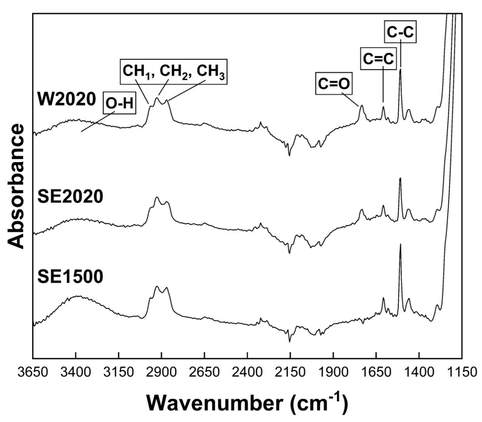
- Glass fibres thermally conditioned at 200–500°C.
- Fibres reclaimed from wind blade using fluidised bed.
- Sizing decomposition by thermogravimetric analysis.
- Fibre surface analysis using FTIR.
- Interfacial adhesion measured using microbond test.

Glass fibre sizing decomposition

- Sizing decomposition onset at 200°C
- Majority of mass loss in 200–400°C region.
- Further mass loss above 400°C attributable to coupling agent degradation.



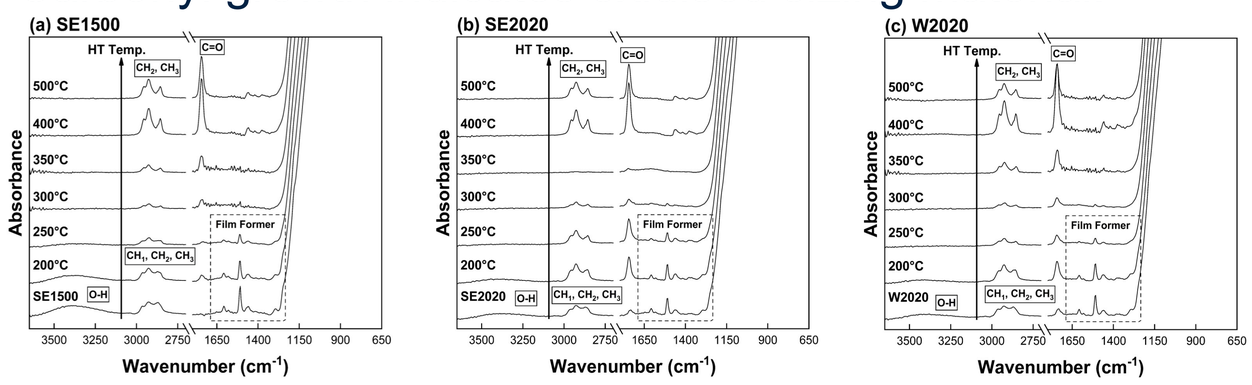
TGA mass loss for glass fibres in air



Glass fibre sizing spectral bands

Fibre surface analysis

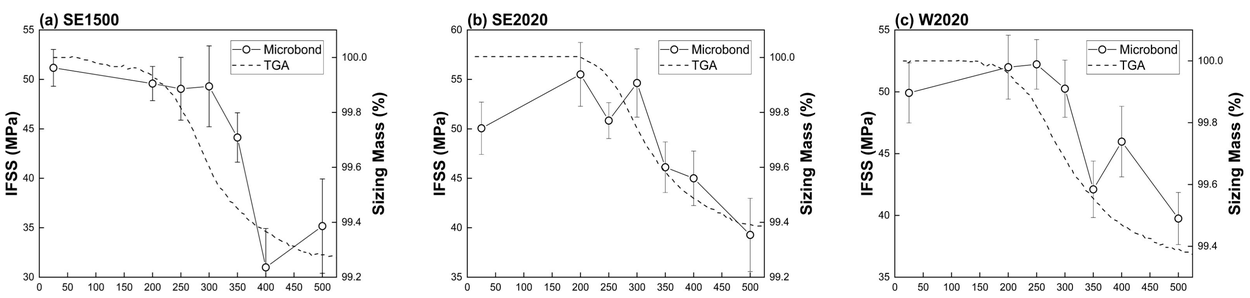
- Hydroxyl group intensity indicative of lubricant removed by 250–300°C.
- Epoxy resin film former decreased with increasing treatment temperature and was removed completely following treatment at 300–350°C.
- Carbonyl growth indicates oxidised sizing material.



FTIR spectra of thermally conditioned glass fibre surfaces

Interfacial adhesion

- IFSS stable up to treatment temperature of 300°C .
- Reduced adhesion onset at 350°C.
- Adhesion at 400–500°C comparable to unsized fibres.



Relationship between thermal conditioning temperature, sizing decomposition, and interfacial adhesion

Conclusions

- Sizing mass loss in in the 200–400°C range attributable to degradation of an epoxy film former.
- Residue of degraded silane coupling agent at 350–500°C.
- Fluidised bed produced pristine glass fibre surface.
- Inverse relationship between IFSS and fibre treatment temperature concurrent with decomposition of sizing.
- Adhesion inhibited at higher treatment temperatures by the accumulation of weakly bound oxidised film former/sizing material on the glass fibre surface.

Future Work (ProGrESS 2022–25)

- £2 million three-year scheme to build pilot recycling facility and deliver a circular model for wind turbine blades.
- Continuous high-throughput reclamation of glass fibres from end-of-life composite materials.
- Reduce the manufacturing carbon footprint of GFRP materials by replacing virgin glass fibre with recycled glass fibre.
- Product development of composites incorporating recycled materials.
- Developing a sustainable solution to support a circular economy for end-of-life GFRP material as a green alternative to the current landfilling approach.