Durability of a Recyclable Thermoset Resin Under Different Temperature And Saturation Conditions

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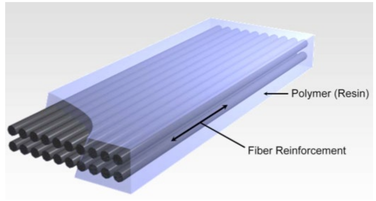
Motivation

- Composites (Resin + Fiber) are frequently used in infrastructure applications
- Thermoset resins lead to generation of non-recyclable waste

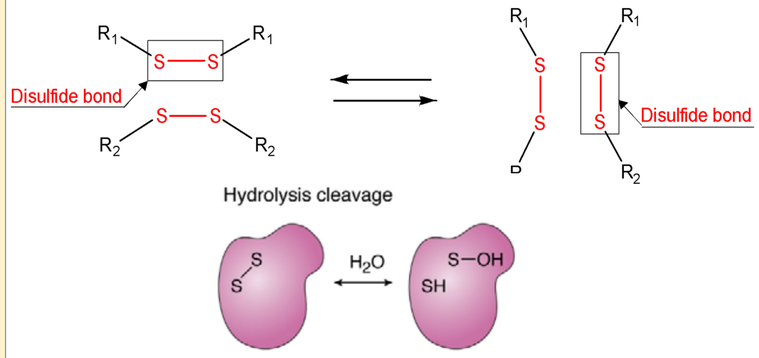


Covalent Adaptable Networks (CANs)

- Polymers with CANs can rearrange their molecular structure through bond exchange while maintaining constant number of crosslinks
- Behave like thermosets but possess beneficial properties of thermoplastics (reprocessable, recyclable, self-healable)

Disulfide Exchange

- In this work, disulfide bonds were integrated into an epoxy resin to enable recyclability
- While imparting recyclability and self-healing to polymer resins, disulfide bonds are susceptible to hydrolysis under mechanical stress in presence of water or alkali which may lead to inferior performance under sustained loading (typical for infrastructure applications of composites)

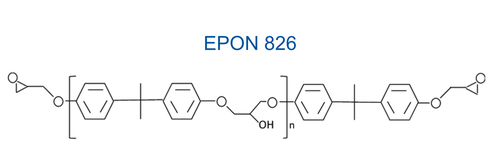


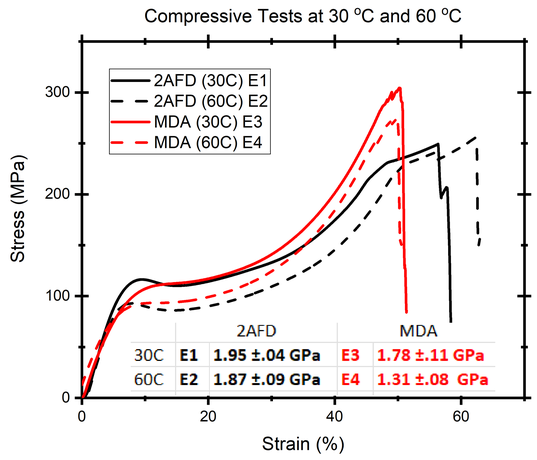
Objectives

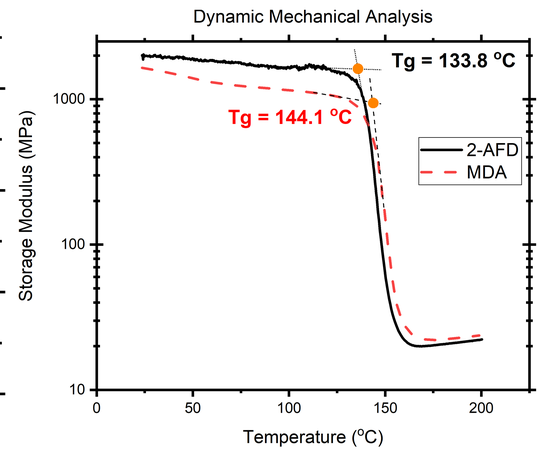
- Synthesize an unrecyclable analog to disulfide resin to serve as control
- Interrogate hydrolytic resistance of recyclable resin by conducting creep experiments on alkali solution-saturated resin samples

Resin Benchmarks

- Recyclable resin exhibits similar mechanical behavior
- Glass transition occurs over a similar temperature range for both resins

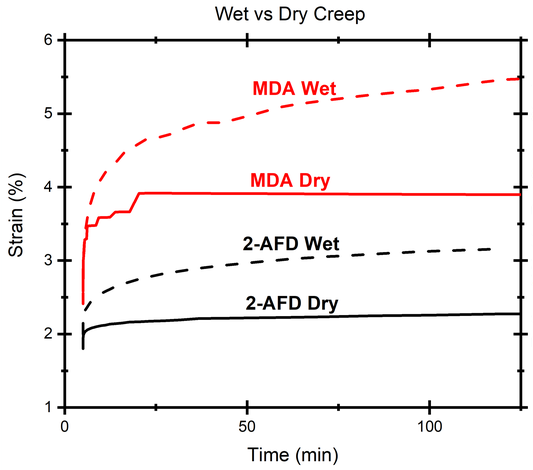


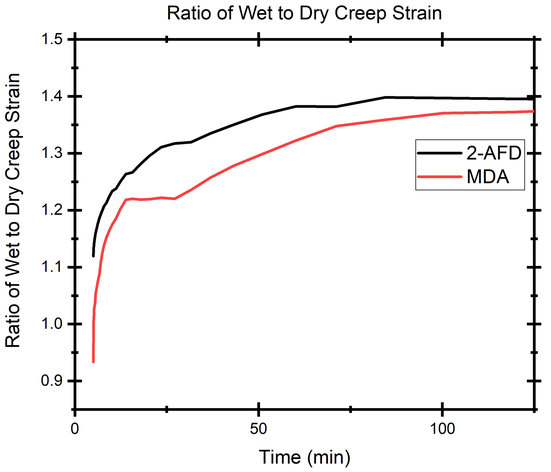




Wet vs Dry Creep Behavior

- Creep experiments conducted in three-point bending at 60 °C under a constant stress representing 80% of yield stress
- No significant difference observed between conventional and recyclable resin

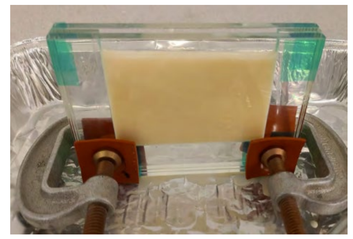




Experimental Methods

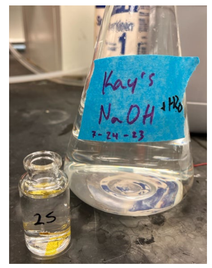
Sample Fabrication

EPON 826 + Hardener (MDA/2AFD) ⇒ Oven



Sample Saturation

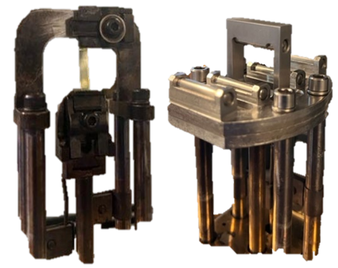
- Solution: 20g of NaOH in 500ml of H2O
- Saturated in Oven at 60 °C until mass of sample stabilized



Compressive Testing

Measure mechanical properties (tensile strength, ultimate elongation, elastic modulus)

Dynamic Mechanical Analysis (DMA)



Measure glass transition temperature and perform creep experiments

Conclusions

- Recyclable and conventional resins have comparable properties
- Disulfide bonds do not appear to exhibit sensitivity to hydrolysis based on the results from short-term creep tests
- Future work should conduct creep tests in wet atmosphere for a longer duration to evaluate the creep resistance more adequately.

References:
[1] Transpo Industries, E-Bond 526 Epoxy Resin Binder High Friction Surface Treatment 2023

Acknowledgements:
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