

DEVELOPMENT OF A RECYCLABLE FLAX FIBER REINFORCED POLYMER (FFRP) COMPOSITE



CENTER FOR COMPOSITE MATERIALS

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Introduction

- Glass- and carbon-fiber composites with a thermoset matrix are typically used in civil infrastructure. These materials have a high embodied carbon and cannot be recycled, which has negative consequences for the environment.
- This work examines flax fibers (as a carbon-negative alternative) and recyclable thermoset (aka vitrimer) to reduce the environmental footprint of composites used in infrastructure. Vitrimers have similar properties to conventional epoxy, but owing to dynamic covalent bonds they can be self-healed, recycled, dissolved or reshaped.

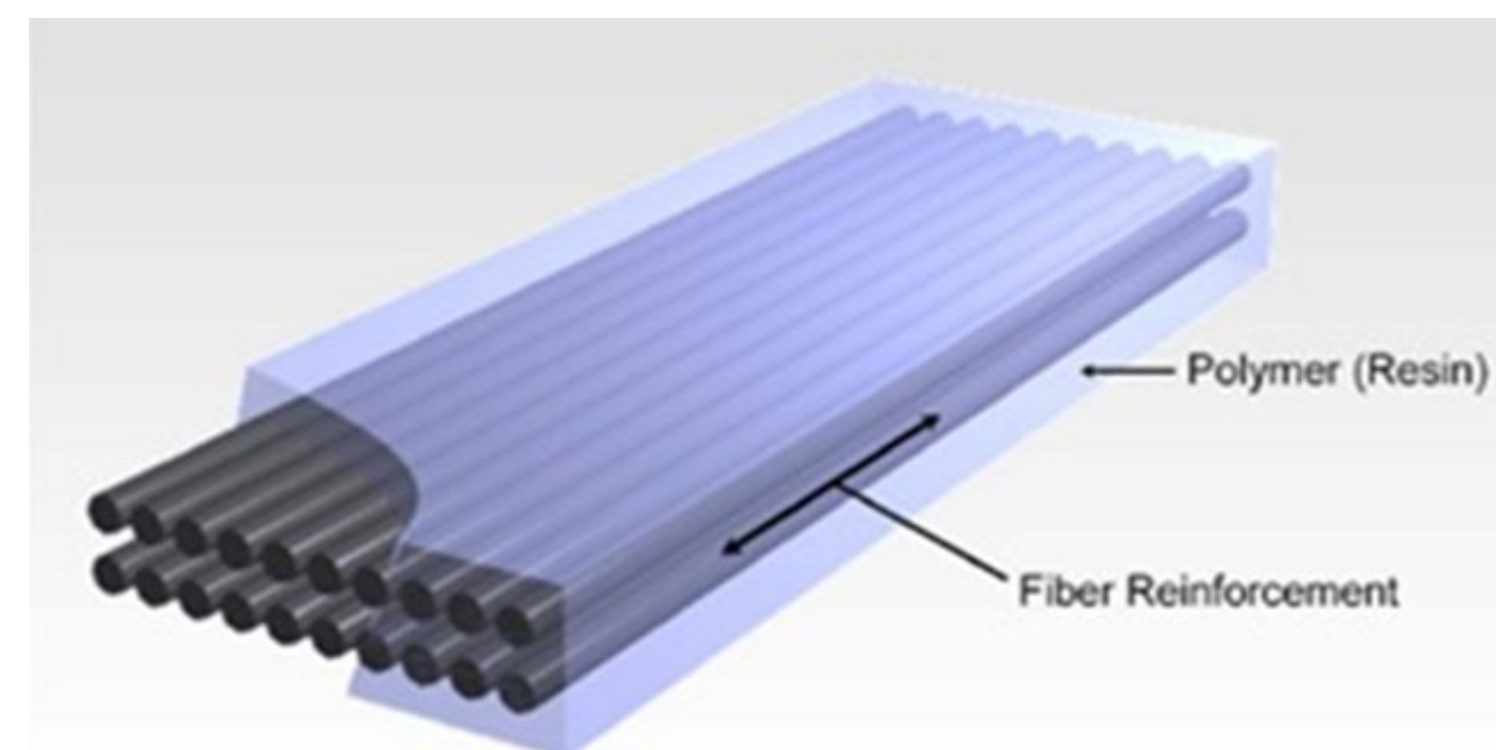


Figure 1. Fiber reinforced polymer composite[2]

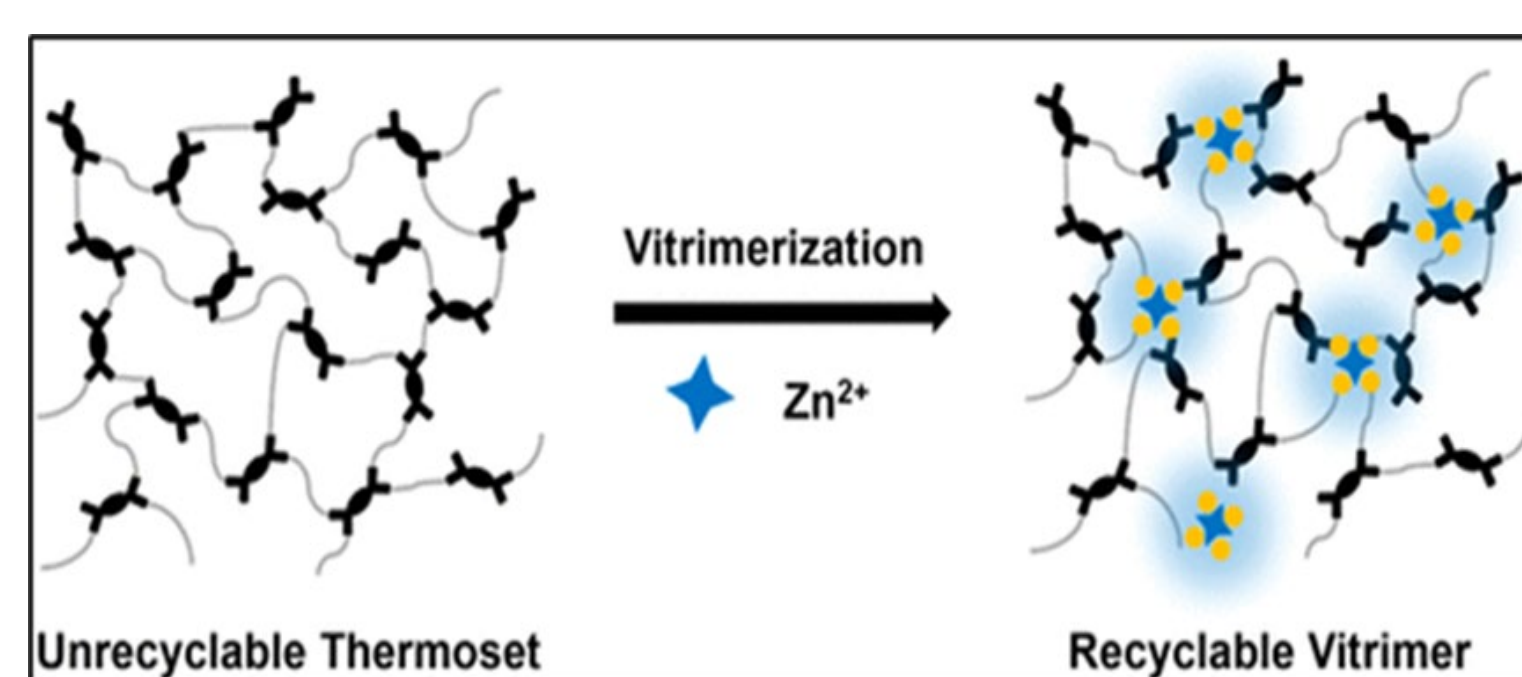


Figure 2. Example of Vitrimerization[3]

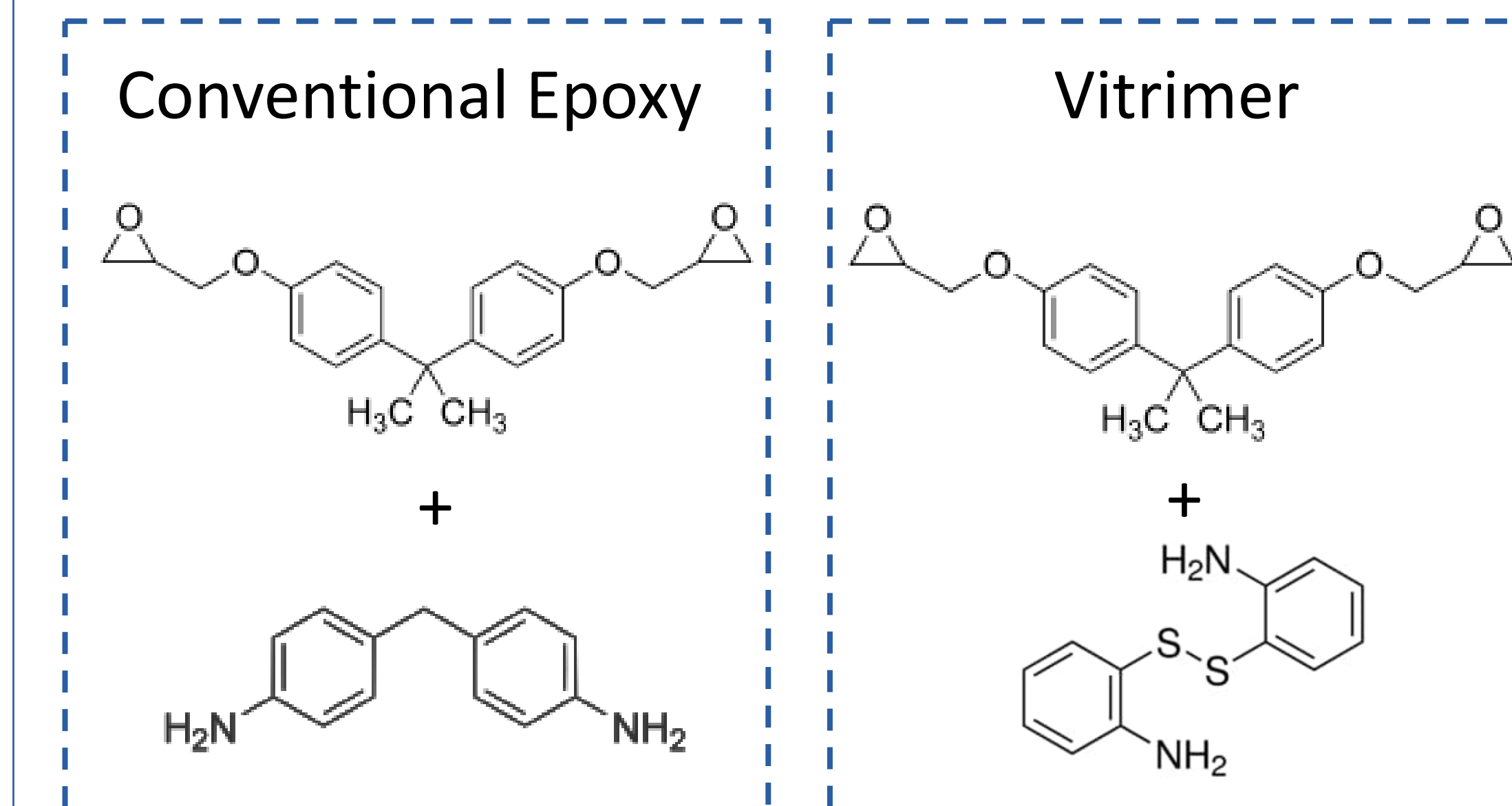
Objectives & Research Questions

- Develop a recyclable FFRP by integrating disulfide bonds in epoxy matrix.
- How do mechanical properties of the recyclable FFRP compare to FFRP with conventional epoxy matrix?
- How does the fiber surface treatment affect the FFRP mechanical properties?

References

[1]Van de Weyenberg I, Chi Trung T, Vangrimde B, Verpoest I. Improving the properties of UD flax fibre reinforced composites by applying an alkaline fibre treatment.
 [2]https://lh3.googleusercontent.com/B7dWB2lQa2s9rn_bICEAQBDSZoV5LHiBNd47Lh4D3tF_ARdZluPJyLiBkrNU_P_on=s166
 [3]https://pubs.acs.org/doi/pdf/10.1021/acsmacrolett.0c00299?cookieSet=1

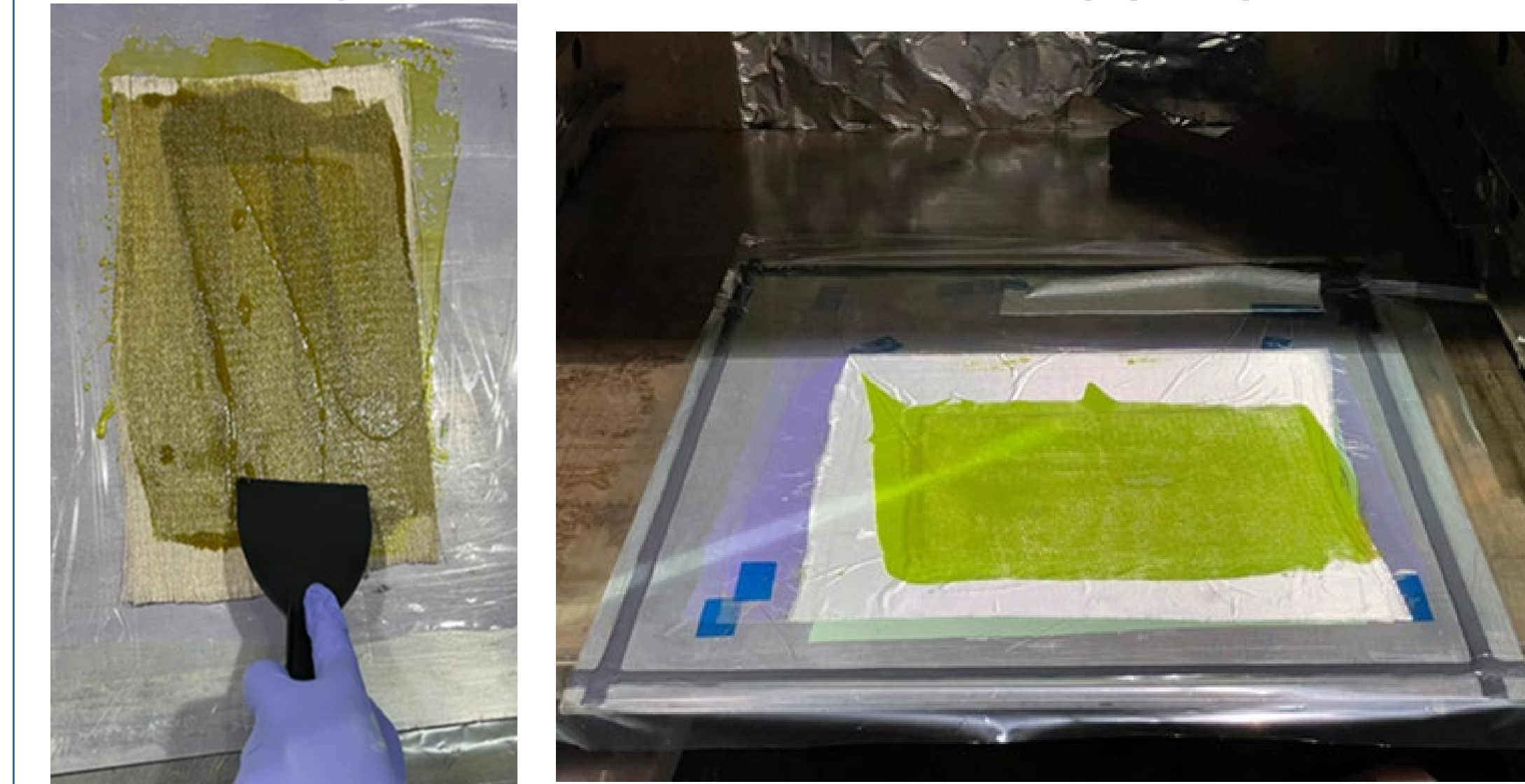
Materials



Fiber surface treatment

Alkali Treatment—fiber fabric was immersed in water with 5% of NaOH for 20 minutes and dry in oven for 8 hours.

Hand Lay-up and Vacuum Bagging



Hand lay-up to saturate flax fiber fabric

Vacuum bagging for consolidation

Tensile Testing

- Tensile tests were performed on FFRP coupons per ASTM D3039.

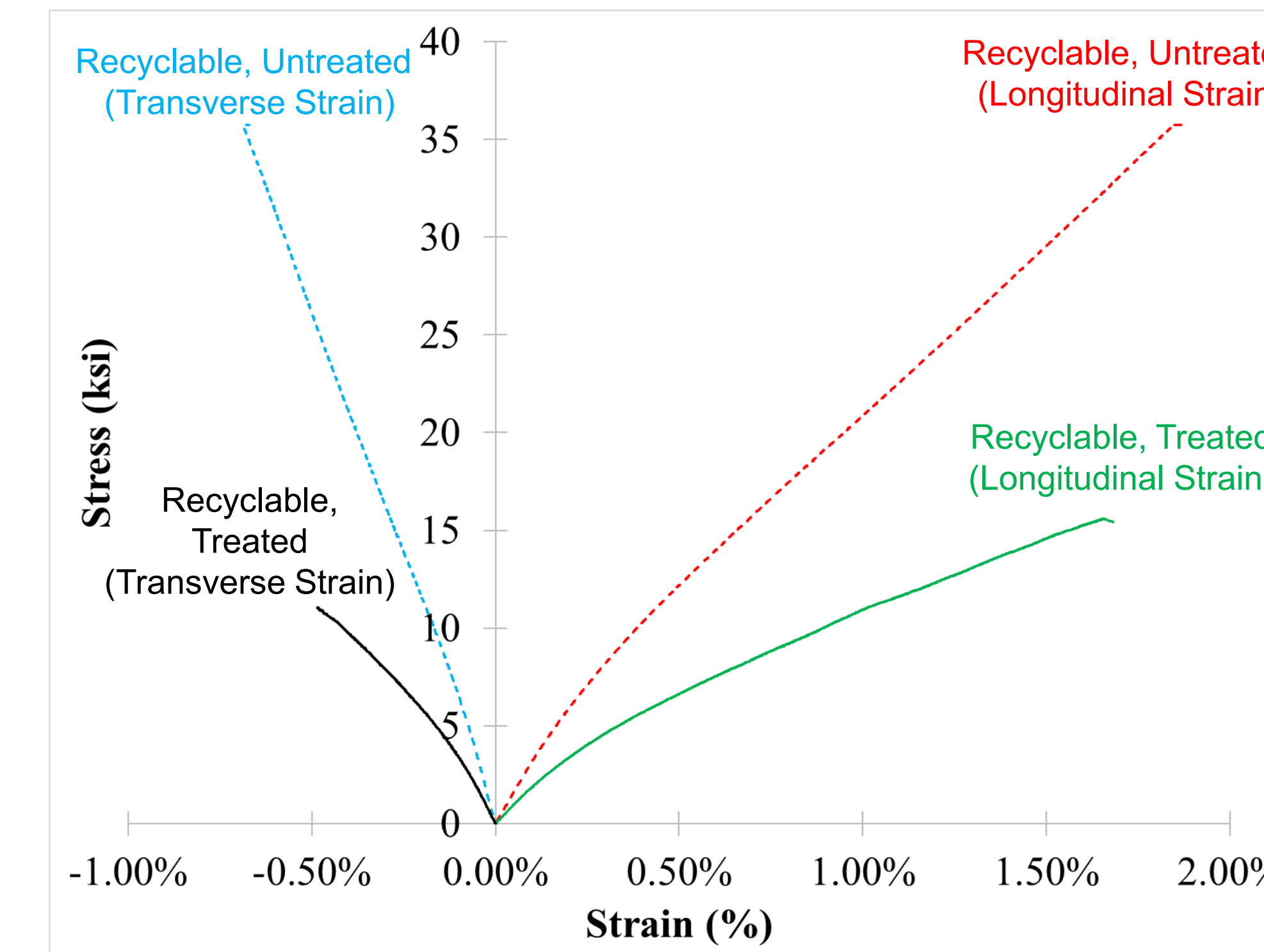


Tensile Test Setup

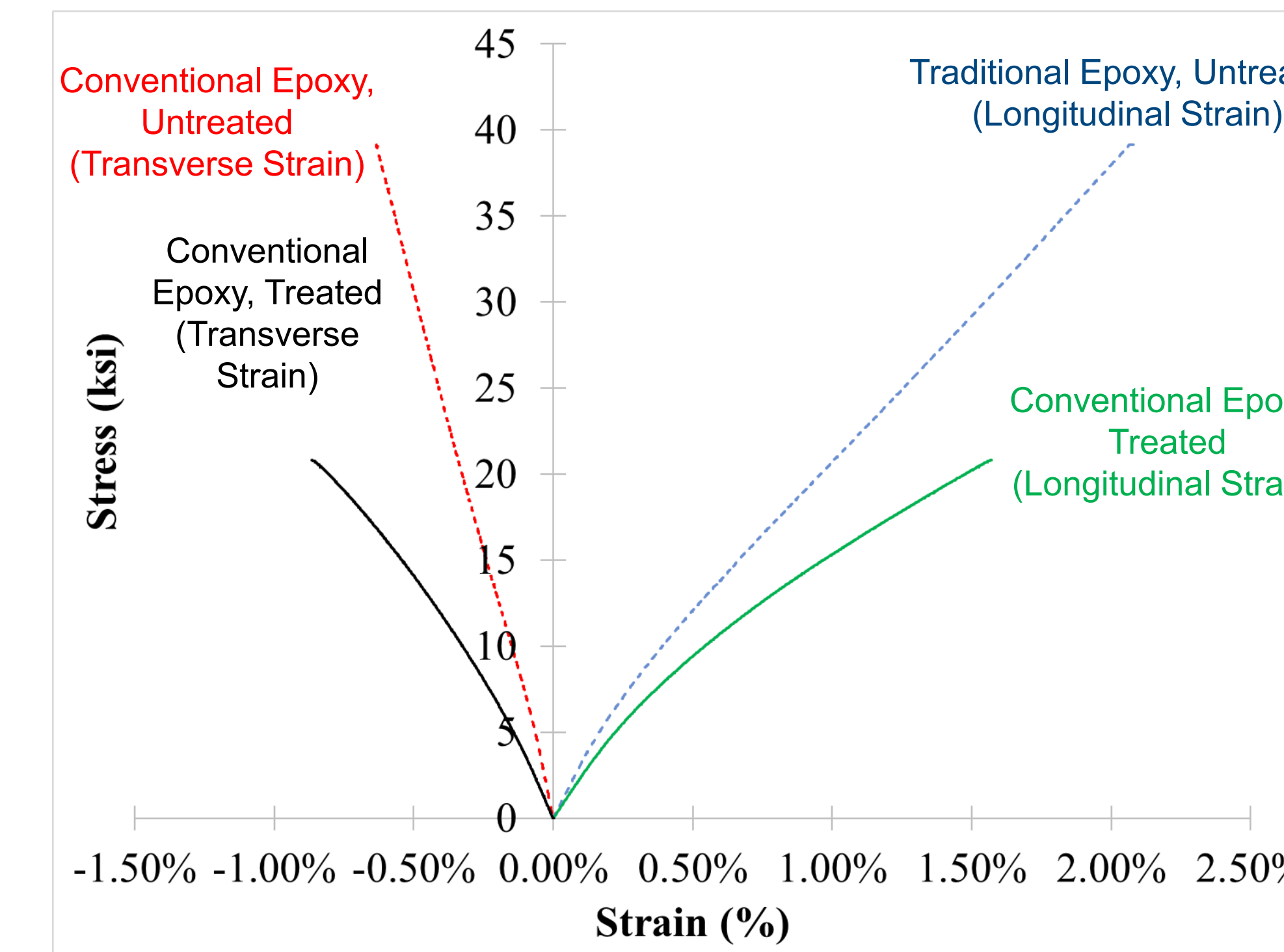
Typical failure modes of recyclable FFRP composites

Results

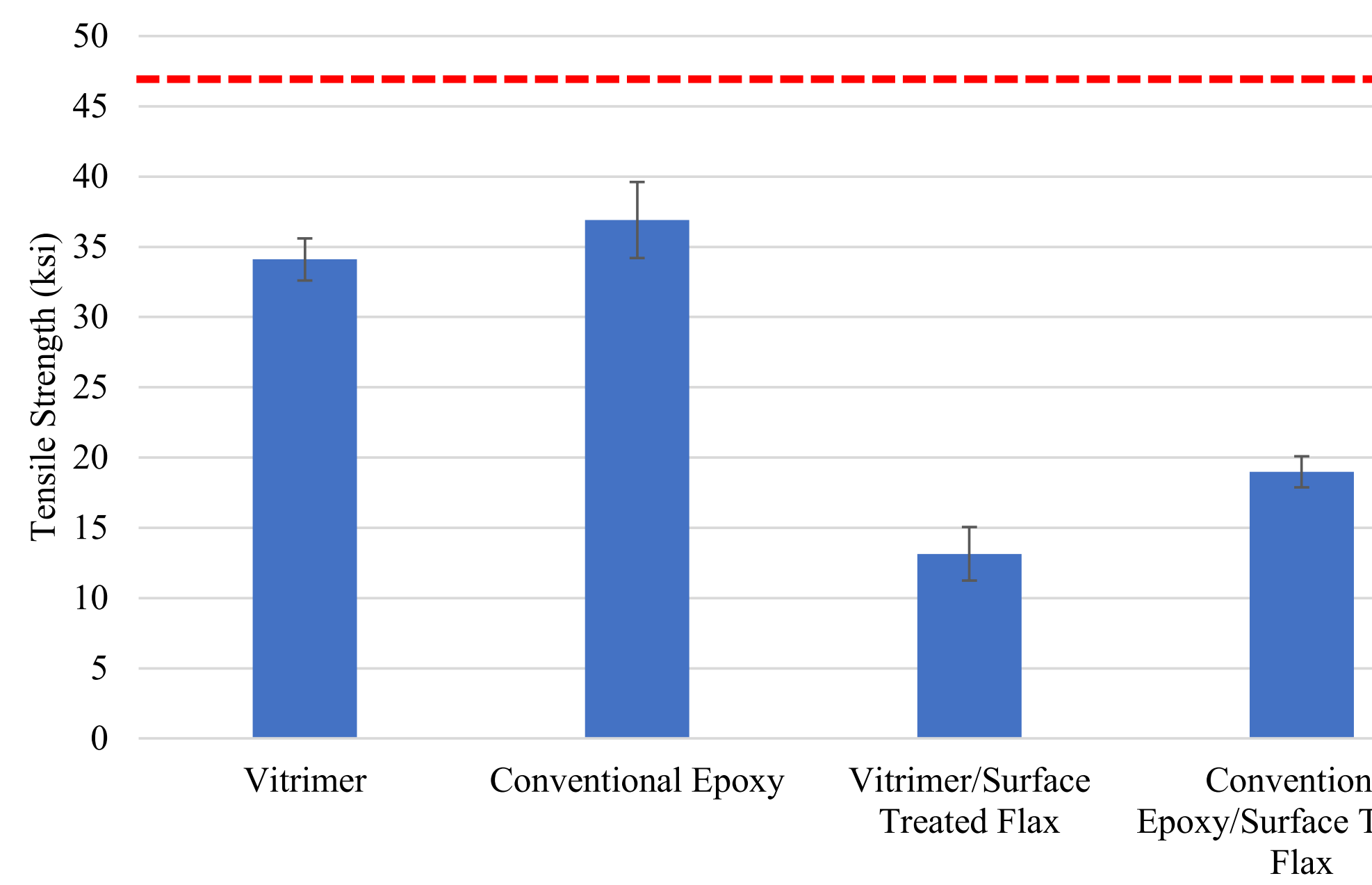
Stress (ksi) vs Strain (%) of Recyclable Composites



Stress (ksi) vs Strain (%) of Conventional Composite



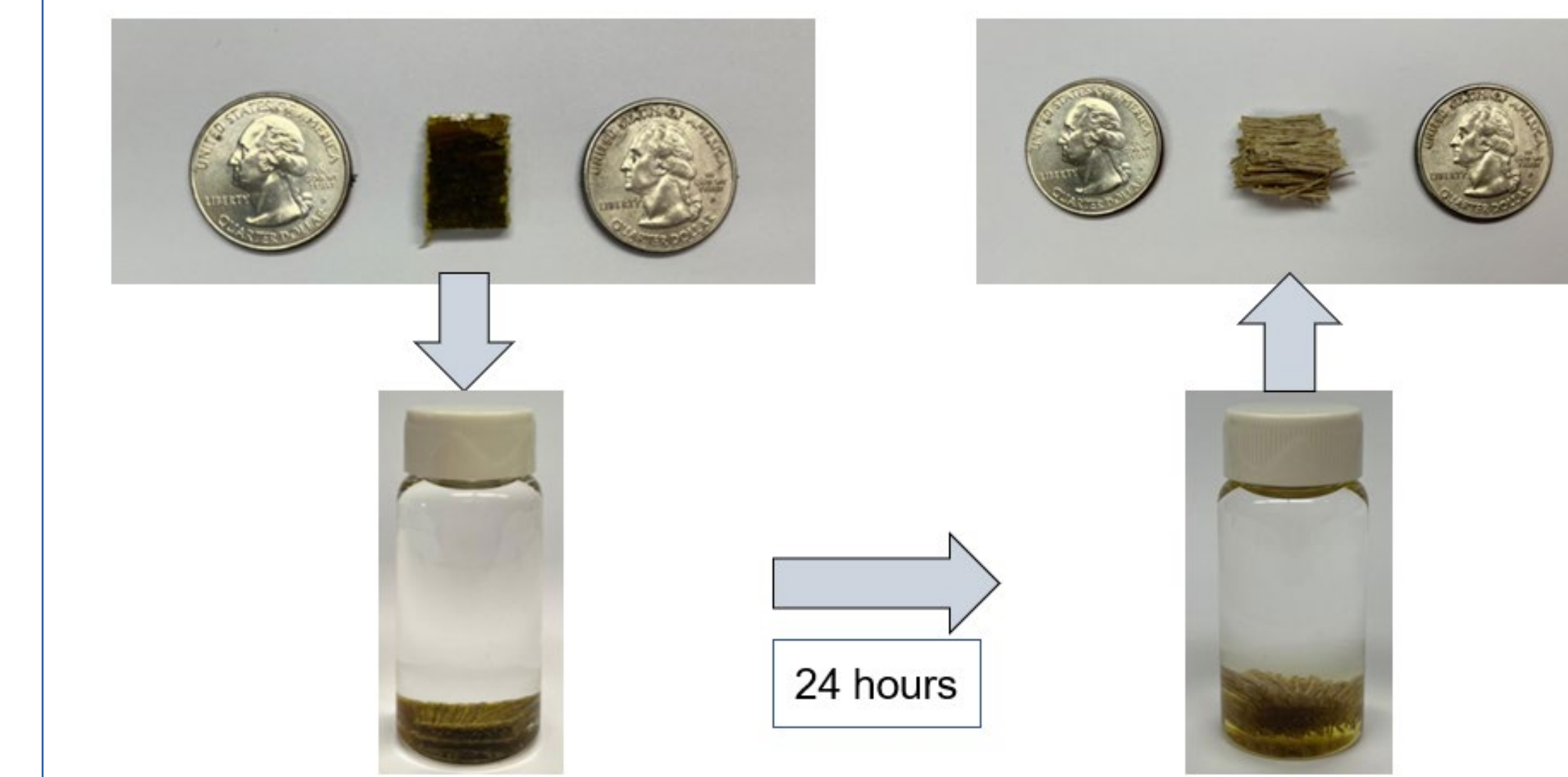
Tensile Strength (ksi) of the different composites



*dashed line indicates flax fiber manufacturer-specified property for composites made with 54% fiber volume fraction and epoxy resin (Aradulite LY 8615/XB 5173).

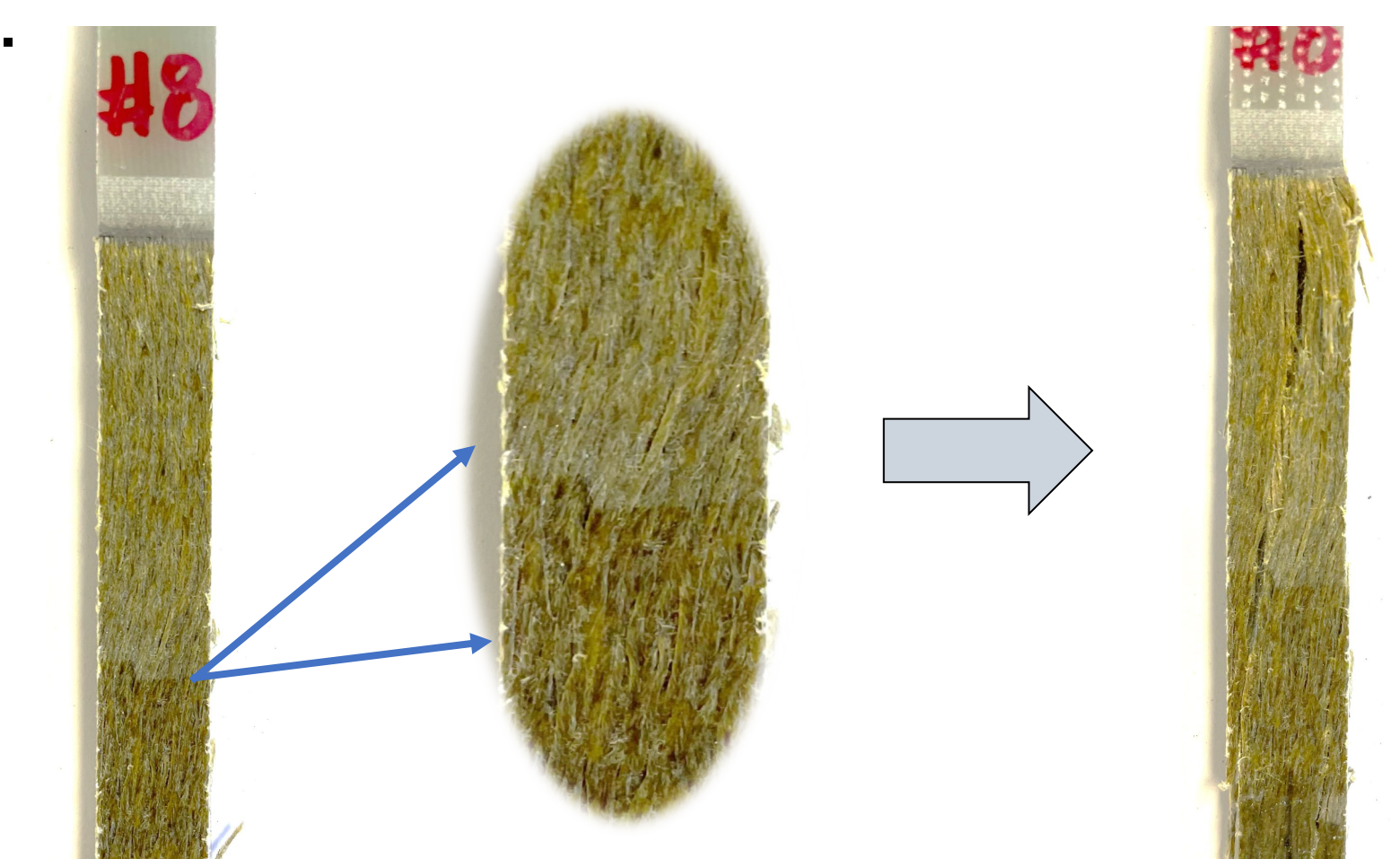
Dissolving recyclable resin

- Solution: dimethylformamide and 2-mercaptoethanol



Conclusions and Future Work

- There was no significant difference in mechanical properties between conventional and vitrimer resin FFRP composites.
- The solution 2-mercaptoethanol with DMF can dissolve the vitrimer resin completely and the flax fabric could be extracted without resin.
- Mechanical properties of composites were below the manufacturer-specified values. This is believed to be due to fiber misalignment introduced during hand-layup process. This effect was especially pronounced in alkali-treated group, resulting in significant strength reduction when compared to untreated fiber group.



- Future work will explore other fabrication methods to eliminate fiber waviness and misalignment. In addition, micromechanical pull-out test and Double Cantilever Beam (DCB) test will be performed to evaluate the effect of alkali treatment on fiber/matrix adhesion.

Acknowledgements

- This material is based upon work supported by the National Science Foundation under Grant No. 2050879.

