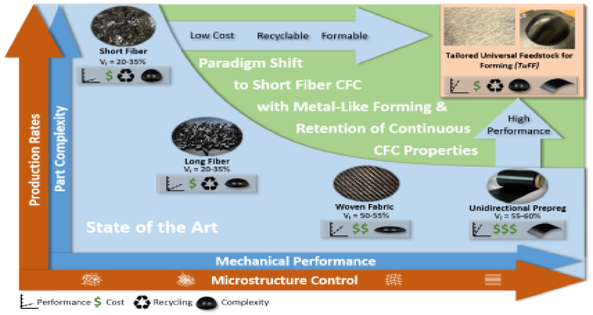
STABILIZING TUFF BY ELECTROSPINNING ULTRA LOW AERIAL WEIGHT BINDER VEIL

Danny Thiemann (B.S.), Dr. Tekin Ozdemir (P.D.), Dr. Joseph M. Deitzel
University of Alabama | University of Delaware | Center for Composite Materials | Department of Mechanical Engineering

Introduction to TuFF

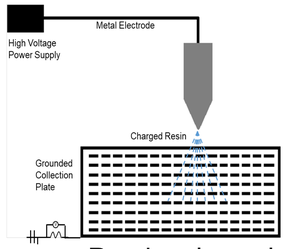
- TuFF (Tailored universal Feedstock for Forming) materials are composites made from sheets of highly aligned discontinuous carbon fibers
- The discontinuous nature of these fibers allow TuFF materials to be made from recycled carbon fibers and still have aerospace grade strength

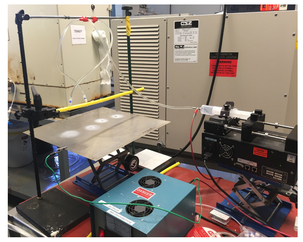


Addressing Dry TuFF Instability

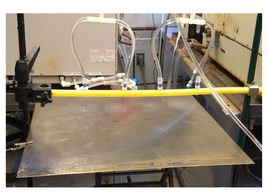
- Dry TuFF sheets have little interactions between their carbon fibers, making them susceptible to falling apart before being cured
- Commercial binders are high aerial weight, which decreases the material's fiber volume fraction and mechanical properties
- Electrospinning allows an ultra low aerial weight binder veil to be evenly applied to dry TuFF sheets, improving their stability without negatively affecting their performance
- Thus far, thermoplastic urethane (TPU) has been used as a binder but is insoluble in water and hazardous to human health
- Aqueous polyvinyl alcohol (PVA) is a water based binder that is eco-friendly and not hazardous to humans

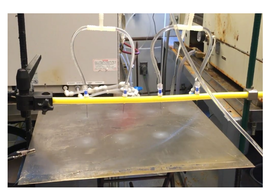
Electrospinning Assembly

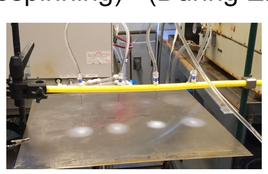




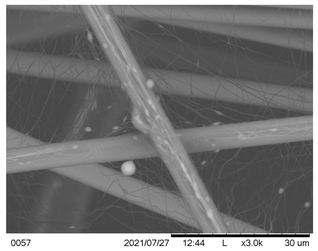
- Previously, electrospinning setups have only used one needle, limiting the size of the material that can undergo electrospinning
- This setup was designed to test scalability by using four needles
- A voltage source was attached to the tip of an injector and a conductive plate creating a potential difference of 7kV between the polymer solution and the conductive plate
- The injector pushed charged resin at a rate of 0.8mL/hr through branched tubing towards four needles resting above the conductive plate
- This caused drops of solution to fall to the plate in a spiral formation known as a Taylor cone from each needle
- The result was an even coating of PVA on the plate across a much wider area than with one needle


(Before Electrospinning)

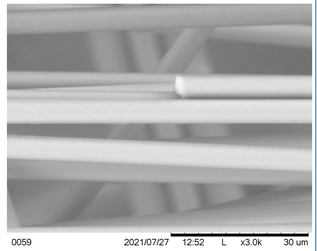

(During Electrospinning)


(After Electrospinning)

Results of Electrospun TuFF

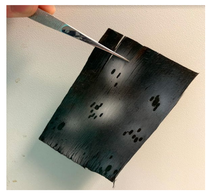


(Figure 1)

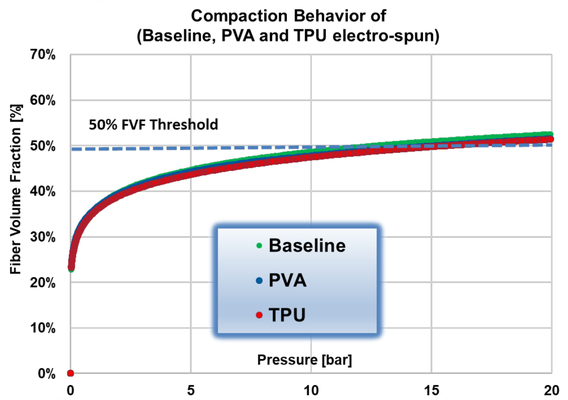


(Figure 2)

- SEM images show the low aerial weight polymer coating on electrospun fibers (Figure 1) versus dry (Figure 2)


(Electrospun TuFF) (Dry TuFF)

- Electrospinning increases stability enough to allow the material to support its own weight



- Compaction tests compare the fiber volume fraction of electrospun TuFF sheets
- This measures the percent of the volume of the material that is accounted for by fibers and how much volume there is for additives like resins and thermoplastics
- The tests showed the TuFF sheets treated with TPU to have nearly the same fiber volume fraction as the baseline, meaning it does not negatively impact the strength of the material

Conclusions

- Unstable dry TuFF sheets can be stabilized by electrospinning PVA onto the TuFF sheets
- Compaction data shows that the low weight of the polymer veil prevents it from impacting the strength of the material
- PVA is a safe, functional, environmentally friendly alternative to TPU for electrospinning TuFF sheets

Future Work

- This project can be built upon by doing compaction tests of PVA electrospun TuFF, further scaling the number of needles, and fully automating the process of running TuFF sheets through the setup
- Compaction tests of PVA electrospun TuFF sheets will allow comparisons between the fiber volume fraction of it and dry TuFF, and will be completed in the coming weeks
- Now that a multiple needle setup has been demonstrated, it is important to determine if there is an upper limit to the number of needles that can be used
- Designing a way to feed TuFF through the electrospinning setup will allow full sheets to be coated evenly

Acknowledgements

The authors would like to thank CA Composites as well as the United States Department of Energy for supporting this project.

Co-Sponsored by:
University Leadership Initiative (ULI)
Partner