Shofner Research Group

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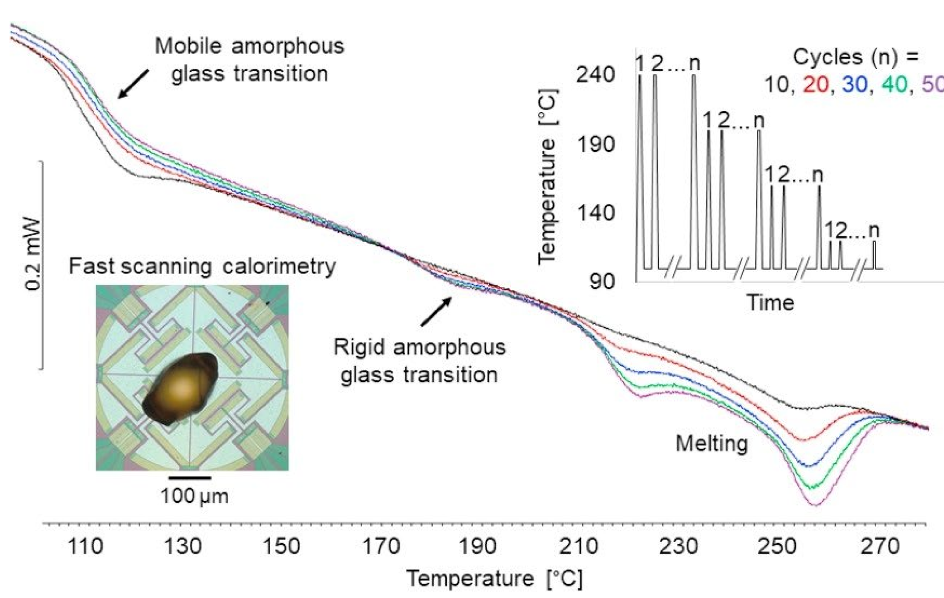
Overview

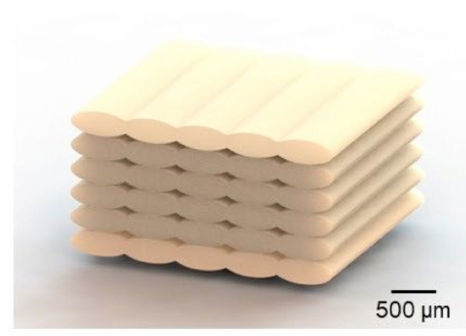
Our research concerns processing-structure-property relationships for polymers and composites. Much of our work examines how scalable processing strategies can be used to produce hierarchical structures, functional properties, and viscoelastic/mechanical performance.

Polymeric Materials for Material Extrusion Additive Manufacturing

We are developing techniques to understand how to use semicrystalline polymers with material extrusion additive manufacturing (MEAM), specifically using capillary rheology, fast scanning calorimetry (FSC), robust design and simulation techniques so that processing issues associated with polymer crystallization can be addressed.



Cycles of heating and cooling from additive deposition in fused deposition modeling parts



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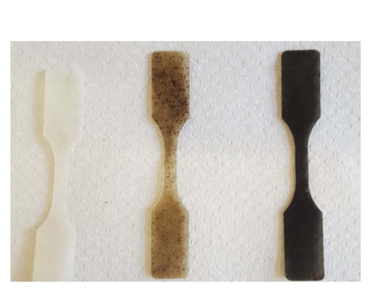
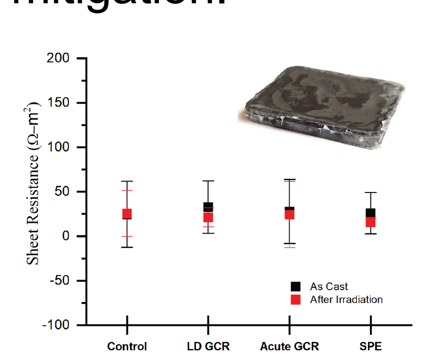
Polymer Composites for Radiation Shielding and Dust Mitigation

As part of the NASA-funded REVEALS Team at Georgia Tech, we are working to understand how polymer nanocomposites could be used to protect humans, equipment, and infrastructure during long-term space missions and habitation. Our current work involves developing chemical modification strategies for graphene oxide (GO) that allows GO to be successfully incorporated into radiation-attenuating polymer matrices, either as a dispersed filler or as a functional coating. Additionally, we are examining the capabilities of GO to address hazards associated with lunar dust through active mitigation.



Improved dispersion of reduced graphene oxide with chemical functionalization (A-rGO).



Electrical resistance of GO laminates was not significantly affected by radiation exposure

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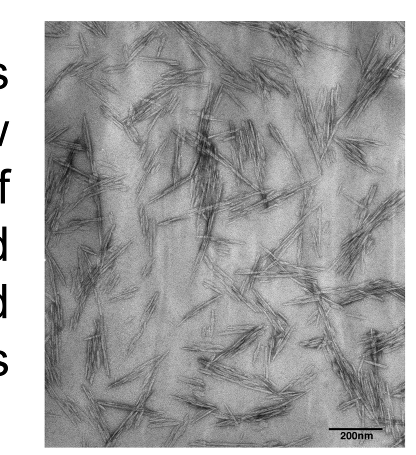
Polymer Composites and Coatings Containing Bio-Based Nanofibers

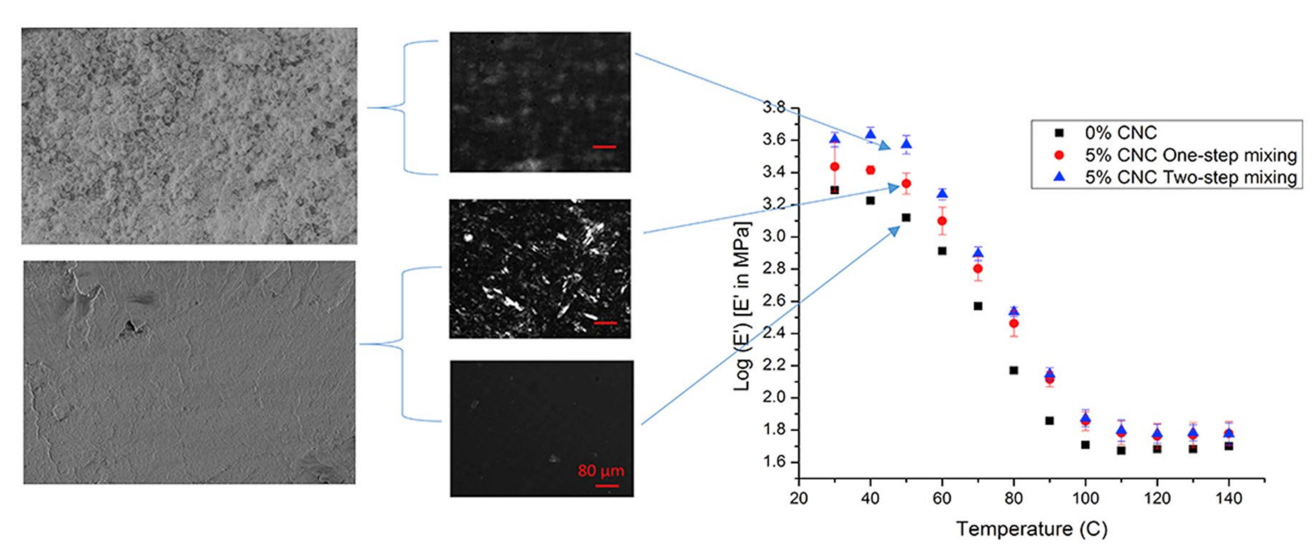
To improve the environmental stewardship of polymers/plastics, bio-based materials are being increasingly investigated as replacement materials or as additives to synthetic materials. In line with these efforts, we are investigating the use of nanocellulose and chitin nanofibers (ChNFs) in polymer composites. Both types of nanofibers are derived from renewable resources, with nanocellulose sourced from precursors such as trees, plants, and organisms and ChNFs sourced from shellfish and fungi.

We are working with a variety of polymer matrices and processing techniques to understand how cellulose nanocrystals (CNCs, a type of nanocellulose) and ChNFs may be incorporated effectively for thermomechanical reinforcement and to discover new routes for processing these systems that exploit their inherent attributes.

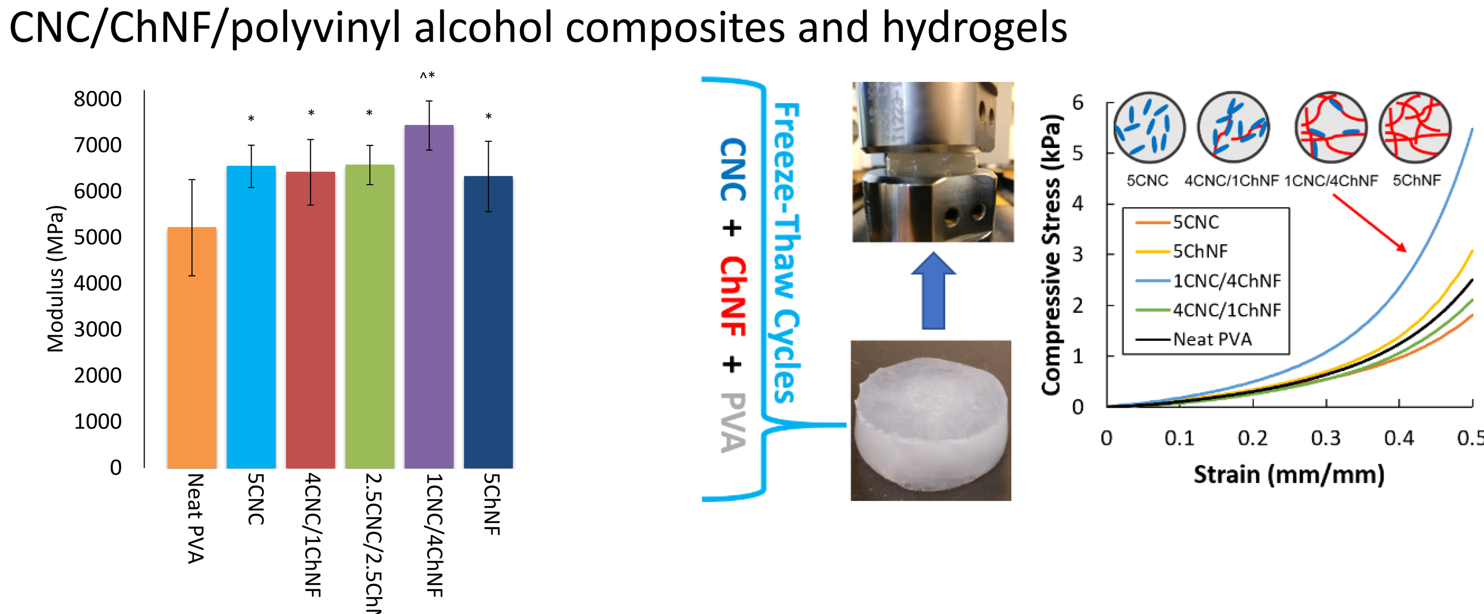


Transmission electron microscopy image of CNCs.

CNC/waterborne epoxy composites



CNC/ChNF/polyvinyl alcohol composites and hydrogels



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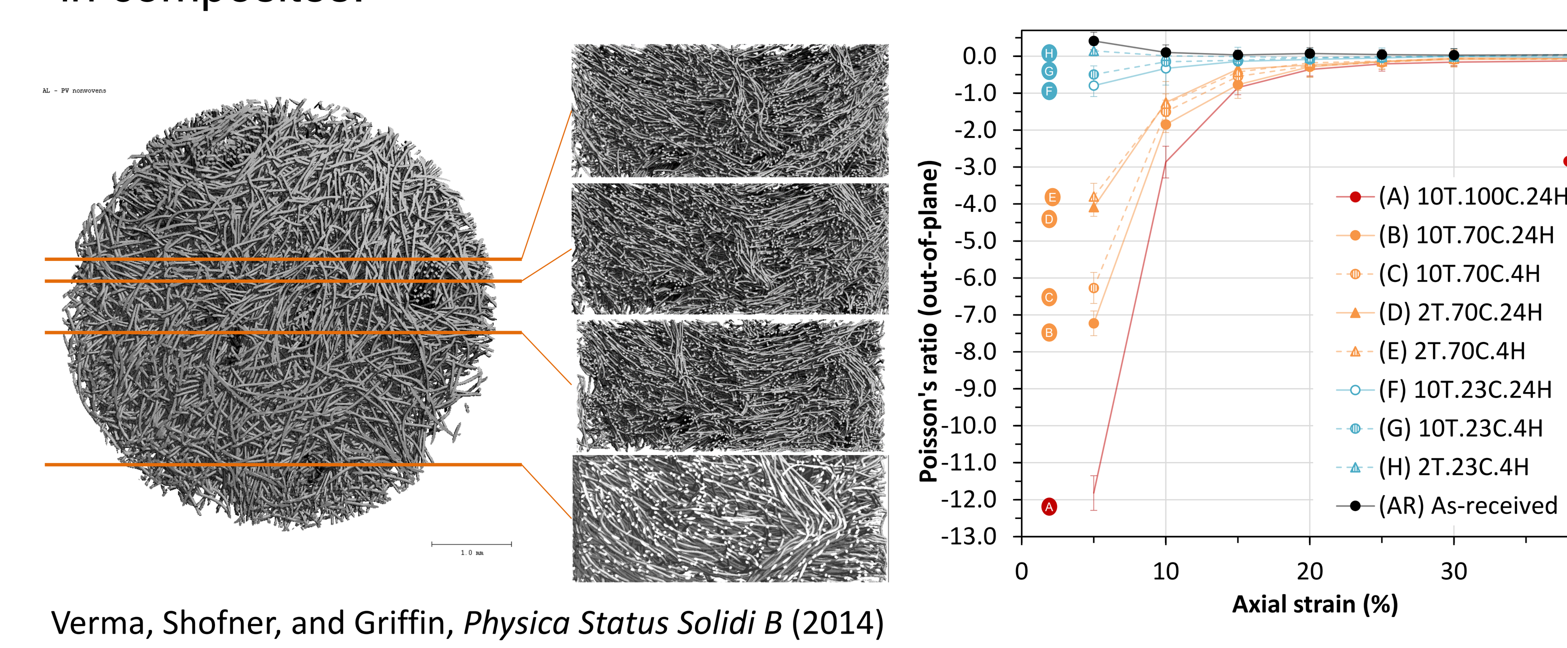
Auxetic Behavior in Fibrous Structures

Materials with an auxetic response have a negative value of Poisson's ratio or similar behavior beyond the elastic regime. Auxetic behavior is unusual, though not necessarily rare, and hence it offers possibilities for unique applications.

We are studying the auxetic behavior of non-woven fabrics to understand what materials and processing variables impact the magnitude of this response and how these structures could be used in composites.



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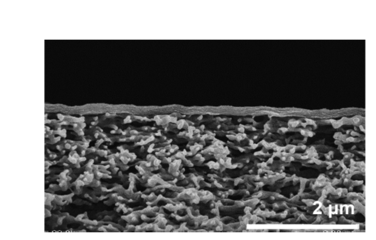
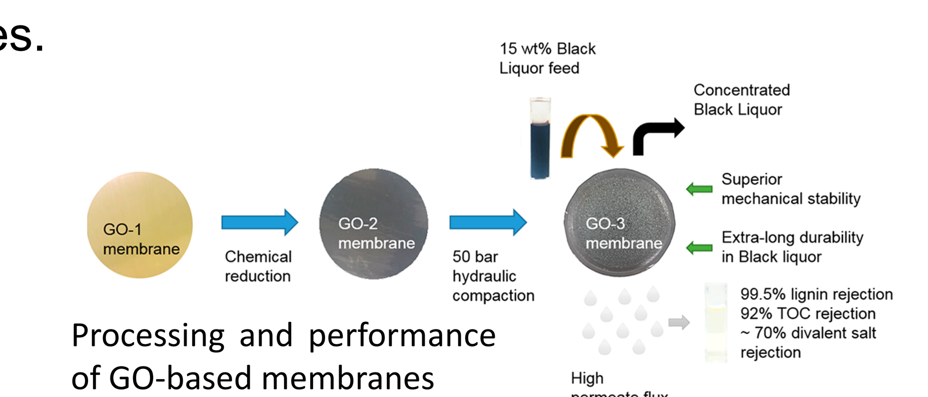
Membranes for Concentration of Black Liquor and Industrial Water Treatment

GO is being used to form new membranes that will withstand the high pH (~12), temperature (90°C), and potential fouling species, present in spent pulping liquor (black liquor) leaving the digester in kraft pulp mills. Beyond improvements in the pulping process, these membranes can be used for separations relevant to biorefining. Current work is examining how these membranes can be used for other industrial water treatment processes.



GO-based membrane on a polyethersulfone support



Processing and performance of GO-based membranes

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Acknowledgements

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