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PhD Thesis Proposal

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Development of MXene-based Electrospun Nanoyarns for Knitted Supercapacitors

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Integrating advanced functions into textiles, including sensing and communicating with nearby electronics, requires the development of wearable energy storage devices. Currently, commercial smart garments utilize conventional battery architectures such as coin cells and pouch cells, which are uncomfortable, unsafe, and impose design limitations onto the final textile device. Supercapacitors, including electric double layer capacitors and pseudocapacitors, are promising technologies for wearable energy storage applications as they can charge and discharge for thousands of cycles and can be made using non-toxic materials. Designing supercapacitors for integration into textiles requires the development of flexible and durable fiber-based electrodes. Once integrated into a fiber, two-dimensional carbides and nitrides, MXenes, are promising electrode materials for wearable storage applications as they have demonstrated high conductivity, high specific surface area, chemical stability, and outstanding electrochemical activity.

The goal of this thesis is to utilize electrospinning as a platform technology to develop nanofiber-based electrodes for knitted supercapacitor devices. The first aim involves electrospinning MXene/polymer composites to develop conductive fibers and yarns with high surface area for electrolyte ion adsorption. Aims two and three focus on expanding the voltage window and improving the energy density of these yarn supercapacitors using electrospun counter electrodes and an ionic-liquid-based gel electrolyte. The final aim involves knitting supercapacitor devices using the yarns developed in aims 1-3. The effect of knit structure (density and porosity) on fabric conductivity and device capacitance will be studied. This work will provide a better understanding of the processability of MXene into fibers, including where MXene flakes reside inside of a fiber, how they interact with different polymers, and how MXene concentration affects the mechanical properties of the resulting fibers. With this information, MXenes will be incorporated into fibers and yarns on a large scale and integrated into knitted devices for smart textile applications.