DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

Department of Materials Science and Engineering,
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Unraveling the charge storage mechanism of MXenes in aqueous zinc electrolytes

Kyle Matthews

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Advisor: Prof. Yury Gogotsi (Materials Science & Engineering, Drexel)

The last decade has seen an ever-increasing demand in the energy storage space, and such has prompted the revolution in lithium-ion batteries. There is a need for higher power and energy density devices, more energy storage platforms, and versatility in the face of grid storage, electric vehicles, and the internet of things (IoT). One of the alternative chemistry solutions that shows promise is zinc-based energy storage systems. Zinc batteries are wide in variety, with varying cost as well as energy and power density. One thing that becomes abundantly clear is that the versatility of the zinc battery chemistries can fill different niches in the energy storage market. It is an industrially mature technology thanks to the primary battery industry, which makes scalability essentially a non-issue. However, its use in rechargeable batteries has been limited so far due to rechargeability issues at both the anode and cathode. Many efforts to improve the reversibility on one electrode decreases it on the other. New electrolyte configurations offering anode stability need to be explored and new materials that are compatible in aqueous zinc chemistries are required to make zinc batteries emerge as a prevalent technology in the energy storage landscape. MXenes are a new and emerging class of 2D nanomaterials discovered in 2011 and have grown into the largest family of 2D materials. This dissertation focuses on uncovering and understanding the material-ion interactions, and the charge storage mechanism of MXenes in aqueous zinc electrolytes. Numerous studies have been published on MXene-ion interactions, and likewise on MXenes being used in zinc-based energy storage systems. However, little work has been done to address fundamental zinc ion interactions with MXenes and even more so have MXenes beyond $Ti_3C_2T_x$ been ignored on this front. To address this, complementary *in-situ* and *ex-situ* characterization techniques were used to study MXene electrodes under multiple conditions in aqueous zinc-based systems. In order to expand the work beyond $Ti_3C_2T_x$ MXenes, new etching and processing protocols were developed and formulated into a guideline for synthesizing V_2CT_x MXene. With these needs met, this work focused on uncovering the difference in charge storage between $Ti_3C_2T_x$ and V_2CT_x MXenes in aqueous zinc electrolytes.