DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

Department of Materials Science and Engineering

Ph.D. Thesis Proposal

February 16th, 2024 2:00 PM (EST)
Hill Conference Room (LeBow 240)

Advancing charge storage properties of layered transition metal oxides by tuning chemistry of the interlayer region via chemical preintercalation synthesis

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Abstract

Layered transition metal oxides (LTMOs) are promising cathode materials for intercalation batteries due to their high working potential and two-dimensional (2D) ion transport channels. Chemical preintercalation is a mild synthesis approach that can be used to stabilize the layered structure and enhance the charge storage properties of LTMOs by introducing foreign species into their 2D interlayer regions before the electrochemical cycling. Bilayered vanadium oxide (BVO) has demonstrated improvements in charge storage properties through chemical preintercalation of Li^+, Na^+, K^+, Mg^{2+}, and Ca^{2+} ions, respectively. However, chemical preintercalation of two or more ions has never been demonstrated. Additionally, the atomic arrangements in the intra- and inter-bilayer regions are not well understood. Furthermore, the correlation between the charge storage properties and the amount & arrangement of structural water in the interlayer region is not established. To understand the structure of the intra- and interlayer regions, atomic pair distribution function (PDF) will be incorporated to investigate the non-crystalline local structure of chemically preintercalated BVOs through both X-ray and neutron total scattering experiments. Additionally, the potential of BVOs to form hybrid electrode materials by chemical preintercalation of diverse functional organic species will be elucidated. The thesis will demystify the structure, chemistry, and charge storage properties enabled by chemical preintercalation synthesis using multiple diffraction and spectroscopy techniques, shedding light on the charge storage mechanisms of the novel chemically preintercalated LTMO electrodes.