<u>Title</u>: Study of Surface Interactions in Sodium-Ion Batteries Using Modified Carbon Films

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Increasing demand for high-density energy storage is driving a search for new alternatives to the high cost and low availability of the lithium. Sodium-ion batteries offer an affordable and earth-abundant alternative to lithium-ion batteries. While significant research progress has been made in developing electrode materials with high charge storage capacities and rate capability, the success of sodium-ion batteries is hindered by unstable formation of the surface-electrolyte interphase (SEI). The SEI forms as a result of electrolyte reduction at the anode surface and causes irreversible capacity loss and interfacial resistance increases. While SEI formation has been the focus of significant research interest in lithium-ion systems, it is still poorly understood in the context of sodium-ion batteries. SEI formation is a highly surface-specific reaction so change in components at the interface can shift the reaction mechanism. Notable differences between sodium and lithium, including increased sodium reactivity and increased solubility of degradation products, mean that knowledge does not directly translate from lithium research into sodium.

In this work, we use carbon thin films as model electrodes to study SEI formation in sodium-ion batteries. By modifying the carbon chemistry and morphology, specific surface interactions are targeted during SEI formation. Electrochemical performance of films is evaluated in a 3-electrode cell, using cyclic voltammetry(CV) and chronoamperometry to form SEI layers. Electrochemical results are correlated with ex-situ measurements of surface chemistry and morphology obtained using X-ray photoelectron spectroscopy (XPS), Raman spectroscopy and optical profilometry.

We have also demonstrated electroactivity of degradation products at potentials relevant to the study of electrode behavior.

A further finding from our work concerns the high reactivity of sodium metal, by which electrolyte degradation and SEI formation occur at the sodium metal surface without electrochemical cycling. As a result of this spontaneous SEI formation, sodium metal can impact the observed surface and bulk behavior of the system when used as a reference electrode.