MSE-2: Fluorination of α-MnO_2 for Energy Storage Devices

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Problem Statement:

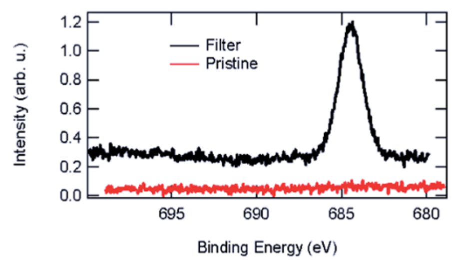
α-MnO_2 has superior specific capacity for use as a cathode in lithium-ion batteries, but suffers from large decreases in capacity upon charge/discharge cycling. Can fluorination of α-MnO_2 improve capacity retention?

Approach:

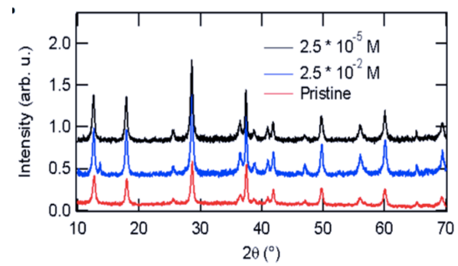
Developed fluorination techniques and compared fluorinated α-MnO_2 with pristine α-MnO_2 for energy storage:

- Optimized parameters for multiple fluorination techniques.
- Characterized samples using XRD & XPS to verify structure was maintained and fluorine was present with no contaminants.
- Tested and compared electrochemical performance and magnetic properties of fluorinated and pristine α-MnO_2.

Results:



XPS showed a strong Mn-F bond (684 eV) and no C-F bond (690 eV) in fluorinated MnO_2 (black)



XRD showed structural preservation after solution treatment at two concentrations

- XRD – α structure was maintained after fluorination.
- XPS – Mn-F bonds with no C-F bonds indicated no contaminants.
- Electrochemical – Fluorination improved electrochemical performance.

Discussion & Conclusions:

- Two successful techniques were polymer degradation, in which a fluoropolymer was heated to release fluorine-containing byproducts that reacted with α-MnO_2, and a solution technique where fluorine salts were dissolved in a solution and stirred with α-MnO_2.
- XRD and XPS showed that the "α" structure was only maintained and fluorine was only incorporated under certain parameters, indicating fluorination process is sensitive.
- Capacity retention improvement in fluorinated α-MnO_2 was theorized to be due to stronger Mn-F bonds compared to Mn-O bonds.

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