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The Role of Structural Water in Electrochemical Energy Storage of Tungsten Oxides

Nanoconfined fluids in materials, such as interlayer structural water, could lead to new mechanisms of electrochemical energy storage with significantly enhanced kinetics. Hydrated tungsten oxides are model materials for the systematic investigation of the effect of structural water in electrochemical energy storage because of their stability in acidic and non-aqueous electrolytes, reversible redox, and multiple hydrated phases. Our results show that hydrated tungsten oxide exhibits surface-limited (pseudocapacitive) kinetics for proton intercalation even with high mass loadings and large particle sizes, which leads to high power capability. On the other hand, the anhydrous tungsten oxide exhibits primarily semi-infinite diffusion-controlled kinetics, typical of battery materials. Within operando atomic force microscopy, it is possible to track electrode height changes on timescales of a few seconds and with sub-Ångstrom resolution. These results on hydrated and anhydrous tungsten oxides show a difference in the structural response of both materials as a function of potential and sweep rate. These results ultimately demonstrate fundamental differences in the structural response of pseudocapacitive, hydrated layered oxides and battery-type oxides that both store charge via intercalation reactions and exhibit the same surface area and morphology.

Veronica Augustyn is an Assistant Professor of Materials Science & Engineering at North Carolina State University. From 2013 - 2015, she was a Postdoctoral Fellow at the Texas Materials Institute at the University of Texas at Austin. She received her Ph.D. in 2013 from the University of California, Los Angeles and her B.S. in 2007 at the University of Arizona, both in Materials Science & Engineering. Her research is focused on the development and characterization of materials for electrochemical energy technologies including batteries, electrochemical capacitors, electrolyzers, and fuel cells. In particular, she is interested in the relationships between material structure and morphology and the resulting redox behavior and electrochemical mechanisms. She also leads an award-winning international project at NC State, SciBridge, which develops renewable energy research and education collaborations between universities in Africa and the U.S. She is the recipient of a 2017 NSF CAREER Award and a 2016 Ralph E. Powe Jr. Faculty Enhancement Award, and is a Scialog Fellow in Advanced Energy Storage from the Research Corporation for Science Advancement.