DEPARTMENT OF CHEMICAL ENGINEERING
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Safe, Inexpensive, and Energy Dense Alkaline Batteries for the Grid Scale

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105 Shillman Hall
11:45am-1:00pm

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Electrical storage at the scale of the power grid is needed to achieve widespread societal use of renewable energy. These next-generation, large-scale energy storage systems will need to be composed of low-cost, easily acquired materials, which will also be safe when used at scale. Grid scale electrical storage encompasses a range of application types, from short-duration power regulation to long-duration energy storage, requiring high capacity discharge over many hours. The well-known Li-ion battery is well-suited to power applications, but may not find widespread use for high-capacity storage due to cost and safety issues. Aqueous batteries based on MnO2 have the benefit of being both safe and extremely cost-competitive, but introduce the complexity of MnO2, which is difficult to cycle in a electrochemically reversible manner. Our work has demonstrated that reversibility can be maintained in Zn-MnO2 batteries, providing high cycle life storage well below the cost of lead-acid batteries. In addition, a new chemical modification to stabilize the MnO2 structure holds promise to allow a water-based battery with the high energy density of Li-ion, but near $50/kWh capital cost.

This talk focuses on original findings on the complex electrochemistry of MnO2. In some regimes of operation, MnO2 stores energy as an H+ intercalation compound, while in others it undergoes complete chemical transformation during the cycling process. Each of these can be exploited in rechargeable battery designs. Our work gives important new insight into the transition between these two regimes, revealing phase transformations normally hidden within sealed batteries, and also pinpointing intermediate phases. We accomplish this using a suite of highly penetrating X-ray operando techniques, which operate in real time at realistic battery discharge rates. MnO2 has traditionally been considered a non-rechargeable material due to its propensity to form insulating spinel compounds, such as ZnMn2O4 and Mn3O4. We demonstrate, for the first time, the reaction pathway leading to these spinels, as well as a chemical modification to render these materials reversible, and thus amenable to rechargeable batteries.

Joshua Gallaway is a research scientist at the CUNY Energy Institute who specializes in the electrochemistry of advanced energy materials. His research focuses on non-uniform current distributions and their visualization using high-energy synchrotron techniques. He received his PhD in chemical engineering from Columbia University in 2007, with advisor Scott Calabrese Barton. After his PhD work he completed a postdoctoral appointment studying non-uniform current distributions in sub-micron interconnects, with advisor Alan West. He then joined the newly-formed CUNY Energy Institute in a position funded by the Wallis Foundation, under Distinguished Professor Sanjoy Banerjee.