Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **2268** Type: **Invited Speaker / Conférencier(ère) invité(e)**

Interface Controlled Anode-Free Sodium Batteries (I)

Wednesday 13 June 2018 13:30 (30 minutes)

The traditional battery configuration incorporates a negative electrode, or anode, which acts as a host insertion material for alkali metal ions. This host anode is necessary due to the unstable metal plating chemistry, especially for lithium, in known electrolyte media. In this talk, I will discuss our recent efforts to develop the anode-free battery, or a full-cell battery configuration that relies on metal plating directly on the negative electrode current collector. However, since the reduction potential for Na/Na+ is less negative than that for Li/Li+, this provides a unique opportunity for an anode-free sodium battery that cannot be realized with a lithium battery since sodium metal plating can be stable in a glyme-based electrolyte. Our observations have demonstrated a correlation between the Coulombic efficiency of a sodium plating/stripping process and the characteristics of the material onto which plating is achieved. In turn, we show that rethinking common host anode materials to instead act as ultrathin nucleation layers bridging the interface between the electrolyte and current collector can lead to Coulombic efficiency exceeding 99.9%. Further, we demonstrate coupling of this anode free approach with two host insertion cathodes including (1) sodiated iron disulphide, which is a low-cost and earth abundant material, and (2) and sodium vanadium phosphate (Na3V2(PO4)3), which is a cathode material with nearly ideal flat voltage profiles. Our results demonstrate the capability to reach high cell-level energy density (400 Wh/kg based on active materials) and/or high round-trip energy efficiency exceeding 98%, which in the latter case will be an important criteria for future large-scale consumer energy storage installations. Finally, I will close with some highlights of our recent research efforts noting that the intersection of (1) understanding the physics of nucleation at heterogeneous interfaces and how this mechanistically controls chemical processes in this system, and (2) engineering approaches in the host cathode assembly to compensate for losses during the cycling lifetime of the battery, can provide an exciting route to low-cost, highly durable, and high energy density batteries specifically tailored for grid-level storage applications.

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Session Classification: W3-2 Energy Storage 3 (DCMMP) | Accumulation d'énergie 3 (DPMCM)

Track Classification: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)