POST LI-ION BATTERIES: MATERIALS AND MECHANISTIC ASPECTS

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Abstract

Li-ion and related battery technologies will be important for years to come. However, society needs energy storage that outperforms current Li-ion batteries in terms of energy density, power density, safety, material sustainability, long-term stability, and cost. Two major directions are being investigated: improved intercalation materials (e.g., multi electron and high voltage materials) and new concepts for anodes (e.g., based on conversion reaction or alloying) and cathodes (e.g., Li-O2, Li-S). The jury is still out on which of the various investigated routes that promise taking energy storage beyond current Li-ion batteries will become eventually a success. Decisive will be how they satisfy the overriding factor of improved energy storage metrics under the constraint of material sustainability and cost. All these new battery chemistries have their particular problems but they have one challenge in common: massive requirements onto the electrolyte and electron conductors that cannot be satisfyingly met by current materials.

We will discuss recent results on two our major research directions: metal-O2 cathodes and electron/ion conducting materials for alloying, conversion and high-voltage materials.

Concerning metal-O2 batteries recent results on electrolyte and cathode stability and the reaction mechanism will be discussed. By this understanding, it has been possible to demonstrate that sustained reversible Li2O2 formation/decomposition can be achieved, essential if the Li-O2 battery is ever to succeed. The insulating nature of Li2O2 presents a particular problem at the cathode; detailed investigation of charge transport in Li2O2 and approaches to mitigate the problem will also be discussed.

Understanding the properties of the solid electrolyte interface (SEI) at the anode and the surface layer (SL) at the cathode in alkaline-ion batteries is important for improving SEI/SL related phenomena including irreversible capacity, interfacial resistance, cycle life and safety. Alloying, conversion and high-voltage materials impose even more severe demands on the interface layers than current graphite anodes or 4 V class cathodes. A resilient SEI/SL permeable to lithium or sodium ions but impeding electron transfer is vital for the long-term performance of a cell. Despite its vital role in the cell there has hardly been work on fundamental understanding of Li+ or Na+ transport in the SEI. We will discuss recent progress towards interfaces with improvements in (i) resilience towards surface strains to avoid cracking upon expansion/contraction of electrode materials (ii) Li+ or Na+ conductivity and electronic insulation, (iii) high voltage oxidation stability, (iv) insolubility in the electrolyte.

Author did not supply full text of the paper.