From Lithium Metal to High Energy Batteries

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Lithium metal has the highest specific capacity of all electrode materials for batteries. It remains, largely, an unsolved mystery as to how to control Li plating in 2-dimensions for 100’s to 1000’s of cycles without the formation of dendrites which cause eventual short circuit and device failure. In order not to deal with the Li metal problem, significant interest has been poured into alternative high capacity anode materials such as silicon (Si) and composites thereof. As our knowledge of Si electrode technology increases, the benefits to energy density within the cell is incremental at best, returning us to the Li metal as a potential solution. However, the cost of Li metal has increased substantially in recent times due to the relative lack of supply and demand for Li precursors elsewhere in the battery value chain.

Li metal is typically manufactured via the production of LiCl from a Li precursor, before being mixed with KCl. The eutectic mixture is then used in a Downes Cell to electrochemically produce Li metal, however, this process is both expensive and environmentally unfriendly. To address this problem, CSIRO has developed a new technology, LithSonic™, to produce Li metal *powder* via carbothermal reduction which does not require the conversion of Li precursors to LiCl or the use of an electrochemical method. From this powder, we now have the opportunity to prepare Li foils where we have the potential to further engineer interfaces and attempt to control Li dendrites on cycling.

One of the leading candidate next generation batteries is Li-Sulfur, however, in order to truly maximise its potential energy density, high sulfur loadings at the cathode are required. With high sulfur loadings come serious issues with polysulfide formation that can effect cycle life of the device [1]. We have undertaken X-ray diffraction and soft X-ray absorption spectroscopy to study crystalline and amorphous sulfur/polysulfides phases, respectively. The phase transitions between these species at different stages of cycling for lithium sulfur batteries based on organic and ionic liquid (IL) electrolytes are investigated in which IL-based cells show better capacity retention. Furthermore, the effect of the $LiNO_3$ additive in the electrolyte is evaluated to identify the optimized concentration.

In this presentation we will overview the carbothermal method for the production of Lithium metal, our work on the use of ionic liquid electrolytes to stabilise the metal interface, which is critical to enable devices such as Li-S, with the goal of developing the next generation of high energy batteries.

References:

[1] M. Barghamadi, A. S. Best, A. I. Bhatt, A. F. Hollenkamp, M. Musameh, R. J. Rees, T. Ruether, Energy Environ. Sci., 7 (2014) 3902.