71st GREEN Open Seminar co-sponsored by NIMS-Softbank Center

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Venue : 515, 5F, NanoGREEN Bldg., Namiki Site, NIMS

From Lithium Metal to High Energy Batteries

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Abstract

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, in the intervening period, the cost of Li metal has increased substantially due to the relative lack of supply and demand for Li precursors elsewhere in the battery value chain.

Li metal is typically manufactured via a LiCl:KCl eutectic mixture that is 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. Today, state of the art for ionic liquid (IL) electrolytes for batteries is the N’N’pyrrolidinium bis(fluorosulfonyl)imide, ($C_x$xpyr FSI) [Best, 2008; Basile, 2016; Yoon 2015]. This cation anion combination has the lowest viscosity and highest ionic conductivity together with the best electrochemical stability for an IL. Once doped with lithium salt, the reductive stability is further improved, however, the viscosity and conductivity is impacted to due to stronger ion-ion interactions.

The challenge for ILs in lithium-ion batteries remains to reduce viscosity and increase the ionic conductivity, specifically the Li transference number, without reducing the electrochemical stability. For Li metal batteries, thinner more stable SEI layers that can accommodate the volume changes of the anode are required and again, improved Li^+ transference numbers to increase the rate capability of the device.

To this end, we have adopted a number of strategies to address these challenges:

- Novel anions & cations [Rüther, 2010];
- Mixing lithium salts [Best, 2014];
- Blending ILs with solvents [Best, 2016];
- Pre-treatment of Li electrodes [Basile, 2016];
- Ionic Liquid – Polymers [Lathrop, 2018].

In this presentation we will overview the carbothermal method for the production of Lithium metal, our work on the use of IL 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:

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