Sigma-Aldrich®
Lab & Production Materials

MilliporeSigma

Advancing Lithium-ion Batteries: Innovative Anodes, Prelithiation, and Sustainable Materials

Webinar FAQs

Pre-Lithiation and Cell Balancing

What is pre-lithiation?

Pre-lithiation is a process to improve battery performance by adding lithium to an anode material before the battery is cycled. Many anode materials react irreversibly with lithium during the initial cycles, which depletes the battery's lithium. Prelithiation compensates for the loss of lithium that occurs in the first cycles and improves the surface of the anode material. These effects improve the capacity retention and cycle life of batteries.

How does cell balancing work with and without pre-lithiation?

Pre-lithiation helps balance the amount of lithium in the cell. Lithium is initially stored in the cathode material. When pre-lithiation is not used, an excess amount of cathode material is required to offset the irreversible loss of lithium that is consumed in the formation of SEI (solid-electrolyte interphase). The quantity of cathode material needed depends on the method chosen to compensate for irreversible losses, which can be determined through calculation. Pre-lithiation helps balance the amount of lithium in the cell, reducing the need to add excess cathode material.

Can you explain the method of pre-lithiation and the associated challenges?

Pre-lithiation can be achieved using a solution method or mechanical contact. Mechanical contact with solid lithium foil or lithium powder can effectively pre-lithiate anode materials, but it can also lead to issues such as void volumes and contact problems. Additionally, mechanical contact methods make it difficult to realize a roll-to-roll process that could be adopted by industry. Solution methods involve soaking the electrode in a highly reducing and lithiating solution. The solution is typically lithium metal dissolved with aromatic molecules like biphenyl (BP) or naphthalene (NP) in a solvent like dimethoxy ether (DME) or tetrahydrofuran (THF). Solution-based pre-lithiation is a simple technique that is easy to introduce into existing roll-to-roll processes. The efficiency is very high, and the pre-lithiation is homogeneous. One challenge is that the solution is highly reactive, which makes handling it more difficult.

What's the standard pre-lithiation method used in the industry, and what's the roll-to-roll process for the solution method?

There is no widely adopted standard pre-lithiation method in the battery manufacturing industry. Experimentation with powder lithium and roll-to-roll processes is ongoing, but no standard method has emerged. One exciting method is the solution-based roll-to-roll process. Here, the electrode is rolled through a chemical bath and immersed for a specific duration. The electrode undergoes lithiation from the solution, followed by washing to remove any excess solution. The concentration of lithium in the bath is controlled easily by the solubility limit of lithium. Excess metallic lithium is added to the coating bath; more lithium dissolves into solution as lithium is consumed by the electrodes. This means that the concentration of lithium does not change or need to be changed during the coating process.

What's the role of washing in the pre-lithiation process, and what solvent is used for washing?

After pre-lithiation, washing is crucial to remove compounds like BP or NP, which are carriers in the pre-lithiation process. These carriers, if not washed out of the anode, could react with other components, such as the electrolyte, during battery assembly. Washing can be done using the same solvent as used in pre-lithiation.

Battery Materials and Anodes

What are the challenges in translating academic research on battery materials to commercial applications?

One of the main challenges in translating academic research into industry is the cost. Additionally, transparent release of data using standardized testing protocols is important for easy cross-comparison in the industry and providing reference benchmarks.

What's the importance of particle size and pre-lithiation for 2D silicon?

The importance of particle size and pre-lithiation for 2D silicon is being studied. The dimensions of the structure and the mechanisms for pre-lithiation of 2D silicon are still under investigation.

Can you compare porous Si and 2D Si for anodes in terms of cost and energy storage?

The cost of materials is highly dependent on the scale at which they are produced. Initial 2D Si is made at a relatively small batch size, and the cost can be scaled up once material demand is established.

Are silicon anodes better than conventional graphite anodes in lithium-ion batteries (LIBs)?

Silicon anodes offer some advantages compared to conventional graphite anodes. For example, silicon has a theoretical gravimetric capacity of 4,212 mAh/g, which is 10 times greater than the theoretical capacity of graphite at 372 mAh/g. If this capacity could be achieved, batteries could store more energy at the same weight, which is particularly important for applications like electric vehicles. However, technical challenges with silicon anodes persist. Currently, the cycle life of silicon anodes is shorter than that of graphite anodes. The shortened life is caused by two major issues: charge-induced volume expansion and unreliable solid electrolyte interphase (SEI) propagation. These issues can be partially addressed by pre-lithiating the silicon anode. Most state-of-the-art anodes use a blend of silicon and graphite to combine the best properties of both anode materials.

Solid-Electrolyte Interphase (SEI) and Electrode Materials

How was the SEI layer formation identified based on the graphs?

AC impedance, SEM, and numerical analysis are some of the electrochemical techniques used to identify the formation of the solid-electrolyte interphase (SEI) layer.

Can prelithiation be used to improve graphite-based LIBs?

Yes, prelithiation can be used to improve graphite-based LIBs.

How can you evaluate the impact of the SEI on the Si-PANI electrode material?

Evaluating the impact of the SEI on the Si-PANI composite involves unique challenges given the amorphous matrix in which the active material is embedded. Insights are derived from capacity loss measurements, showing improved capacity retention compared to Si alone.

Miscellaneous

Can you comment on the importance of the particle size and whether the pre-lithiation differs for 2D silicon versus other forms of silicon?

Research on 2D silicon is ongoing, and while the dimensional comparison with well-established studies on 3D silicon particles has not been completed, it is currently underway.

This Q&A compilation summarizes all inquiries and answers fielded during the live session, as well as those that could not be addressed due to time constraints.

If you missed the session, you can view it **on demand**.

MilliporeSigma
400 Summit Drive
Burlington, MA 01803

SigmaAldrich.com

MS_FL13998EN 58558 09/2024