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1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Zhaoyang Fan
Wenyue Li
Shu Wang

Contact

Physical Sciences Team

Functionalized Bacterial Cellulose Nanofiber-Based Battery Separators

Background

Lithium metal batteries (LMBs), including lithium sulfur batteries (LSBs), use lithium metal as the anode instead of the conventional graphite anode used in lithium-ion batteries (LIBs), and can deliver an energy density that is significantly higher than LIBs. In LMBs, the cathode can be the conventional cathode materials used in LIBs, or it can be other materials such as sulfur which offers further improved energy density at a potentially lower cost.

There are still several challenges to overcome with using lithium metal as the anode before LMBs can be made available for widespread use. The formation of lithium dendrites and the associated unstable solid electrolyte interface (SEI) are the two most challenging obstacles. Lithium dendrites can penetrate the separator to shorten the cathode and the anode, raising severe safety concerns. They can also detach from the anode and form dead lithium after encapsulation by insulating SEI. This exposes the fresh lithium to the electrolyte, which causes a continuous reaction between lithium and the electrolyte, resulting in fast capacity loss and low Coulombic efficiency during battery operation.

In the stepwise conversion chemistry between octasulfur (S8) and dilithium sulfide (Li2S), many intermittent polysulfide species are formed, most of which are dissoluble in the electrolyte. The shuttling of these polysulfides between the cathode and the anode gives rise to capacity fading, enhanced corrosion of the lithium anode, and self-discharge.

Invention Description

Researchers at Arizona State University have developed an oxidized bacterial cellulose polymer that is functionalized with carboxyl groups and SiO2 nanoparticles to serve as a separator for Li-metal and Li-sulfur batteries. The separator exhibits good mechanical, chemical and wettability properties and can be used at higher temperatures compared to conventional polyolefin-based separators. The novel separator has shown to smooth the Li ion flux via strong interaction between Li ions and the SiO2 particles regulating the Li metal plating and stripping while also curbing the polysulfide shuttling process. Cycle life data in coin cell tests showed no formation of Li metal dendrites after 200 cycles whereas dendrites were observed in a polyolefin based Celgard separator.

Potential Applications

- Lithium-metal batteries
- Lithium-sulfur batteries

Benefits & Advantages

- Improved stability
- Lower polarization voltage
- Higher Coulombic efficiency
- Uniform coatings resulting in better structure and composition for the separator

Related Publication: Functionalized bacterial cellulose as a separator to address polysulfides shuttling in lithium–sulfur batteries - ScienceDirect

Related Publication: Oxidized bacterial cellulose functionalized with SiO2 nanoparticles as a separator for lithium-metal and lithium–sulfur batteries | SpringerLink