Production of Alkali Sulfide Cathode Materials for Next Generation Rechargeable Batteries

Xuemin Li, Yongan Yang, and Colin Wolden

Summary: A method to produce hierarchically structured alkali sulfide cathode materials.

Description: Meeting the demands of advanced consumer electronics and electronic vehicles requires next generation rechargeable batteries with greater specific-energy and energy-density that current lithium ion batteries. Alkali sulfide (M\textsubscript{2}\textsubscript{S}, M = Li and Na) cathodes have great promise for enabling a number of “beyond-lithium” technologies, including metal-sulfur, graphite-sulfide, and silicone-sulfide batteries. Significant efforts have been invested to develop M\textsubscript{2}\textsubscript{S} cathodes. M\textsubscript{2}\textsubscript{S} nanoparticles serve as a good model system as their small dimensions and high specific surface area enables higher capacity, greater cycling stability, and faster charging/discharging kinetics, but face the challenge of achieving both high specific-capacity and capacity-density. In addition the current methods for production of M\textsubscript{2}\textsubscript{S} nanoparticles are energy intensive and not viable on a commercially scale. A number of practical challenges also exist when M\textsubscript{2}\textsubscript{S} nanoparticles are directly used in batteries. M\textsubscript{2}\textsubscript{S} hierarchical structures (M\textsubscript{2}\textsubscript{S}-HSs) have the potential to overcome many of these limitations. The M\textsubscript{2}\textsubscript{S} hierarchical structures developed in this work are composed of micrometer-sized secondary clusters of M\textsubscript{2}\textsubscript{S} nanoparticles that are wrapped in a carbon scaffolding. These secondary structures have the benefits of both nanoparticles (improved cyclability and high specific capacity) and of bulk materials (high capacity density). The secondary structures are wrapped within a carbon-scaffold to form hierarchical structures and electrical interconnectivity among primary nanoparticles is created producing an effective electrode material.

Main Advantages of this Invention:

- The M\textsubscript{2}\textsubscript{S} secondary structures are produced through a one-step process, without the need to first synthesize M\textsubscript{2}\textsubscript{S} nanoparticles. The reaction is thermodynamically favorable, spontaneous, rapid, and complete, and proceeds at room temperature and pressure. The auxiliary reagents can be recycled without any treatments, enabling a continuous process for manufacturing.
- A polymer coating on the secondary structures is applied and is resistant to the solvent used to form the carbon-scaffold.
- The carbon scaffold enables electrical interconnectivity among the primary nanoparticles, facilities M-ions transport throughout the whole structure, and blocks the electrolyte and prevents the formation of detrimental species inside of the hierarchical structures.
- Method completely consumes the reactant H\textsubscript{2}S, which is a major industrial pollutant.

Potential Areas of Application:

- Batteries
- H\textsubscript{2}S removal

ID number: 16020


Opportunity: We are seeking an exclusive or non-exclusive licensee for implementation of this technology.

For more information contact:
William Vaughan, Director of Technology Transfer
Colorado School of Mines, 1500 Illinois Street, Guggenheim Hall Suite 314, Golden, CO 80401
Phone: 303-384-2555; e-mail: wvaughan@mines.edu