SnS_2 and C-SnS_2/Si anode active materials for Li ion batteries

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Tin-based chalcogenides such as SnS_2 have been investigated as potential anode active materials for Li-ion batteries due to their high theoretical reversible capacities (e.g., 644 mAh g^{-1} for SnS_2). These high capacities are associated with the reversible alloying of Sn with Li after the conversion reaction of SnS_2 to Sn and Li_2S. The hydrothermal method is known to be a facile, sustainable procedure to synthesize electroactive materials without utilizing surface active agents and other additives. However, the influence of precursor ratios on crystal structure, particle morphology and electrochemical performance is usually not carefully explored in literature. Therefore, in present work, SnS_2 was synthesized using different ratios of tin chloride and thioacetamide to investigate the structure-performance-property relationships of SnS_2 anode active materials.

The synthesized SnS_2 powders exhibited varied degrees of crystallinity and plane orientations depending on precursor ratio, as observed by Rietveld refinement of the measured X-ray diffraction (XRD) patterns. Specifically, increasing the molar ratio of S to Sn in solution yielded in more crystalline SnS_2 products with intensified crystal plane orientations. During electrochemical analysis of the electrodes, which were prepared by water-based processing, a self-healing property could be identified, where the highly layered crystals showed reversibility of the conversion reaction of Sn and Li_2S back to SnS_2.

Also, we synthesized C-SnS_2/Si composite anode material with a high energy density and excellent cycle stability via solid state method. The structure of C-SnS_2/Si composite composite material is sandwiched like, where active materials are integrated into conductive porous polymer matrix. Using the structural advantages of composite material, the lithium storage mechanism of tin disulfide and silicon materials have been improved from three aspects: alleviating the volume expansion effect, improving the stability of the solid electrolyte interface (SEI), and enhancing the electrical conductivity. The material exhibits good performance when applied to lithium-ion battery anodes. At the current density of 0.1 Ah g-1, the specific discharge capacity of the electrode material is maintained at 510 mAh g-1 after 200 cycles for C-SnS_2/Si material and 720 mAh g-1 after 100 cycles for C-SnS_2 composite anode material.

Keywords: tin disulfide anode; composite; carbon coating; matrix; silicon anode; solid state; synthesis

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