

Single-Source Precursor Derived SnS₂/Expanded Graphite for Lithium-Ion Battery Anodes

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Abstract

Single-source precursors (SSPs) offer distinct advantages over conventional dual-source routes for the synthesis of metal sulfides, enabling improved phase purity, precise stoichiometric control, high reproducibility, and tunable morphology. Among metal sulfides, SnS₂ - a layered two-dimensional material - has emerged as a promising anode for lithium-ion batteries (LIBs) due to its high theoretical capacity (~1231 mAh/g), which is nearly three times that of commercial graphite. Furthermore, SnS₂ operates at a relatively higher operational potential (~0.6 V vs. Li/Li⁺) than graphite (~0.01 - 0.2 V vs. Li/Li⁺), providing an enhanced safety margin and making it attractive for fast-charging LIB applications. Most reported SnS₂ syntheses rely on toxic organotin-based SSPs and oleylamine (NAPF 310) solvents, raising environmental and health concerns. In this work, an organotin-free SSP, Sn(S₂CNET₂)₄, was employed in ethylene glycol (NAPF 110) to synthesize SnS₂ nanosheets via a solvothermal decomposition route. The electrochemical performance of SnS₂ was evaluated in lithium half-cell configurations. Bare SnS₂ delivered specific capacities of 521 and 30 mAh/g at current densities of 0.1 and 2 A/g, respectively, but exhibited poor capacity retention and showed capacity loss of ~33% due to volume expansion and poor intrinsic electrical conductivity. To overcome these limitations, SnS₂ was integrated with expanded graphite (EG) to form a SnS₂/EG composite. The composite showed significantly enhanced capacities of 788 and 449 mAh/g at 0.1 and 2 A/g, respectively, with good capacity retention and only ~11% capacity loss during rate recovery. Density functional theory-based calculations reveal the formation of a built-in electric field at SnS₂/EG interface, which lowers the lithium-ion diffusion barrier, facilitating faster ion transport and improving the overall electrochemical performance. Overall, this study highlights an effective strategy combining green SSP synthesis and conductive EG integration to develop high-performance and safe SnS₂-based anodes for next-generation LIBs.

References

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Figures

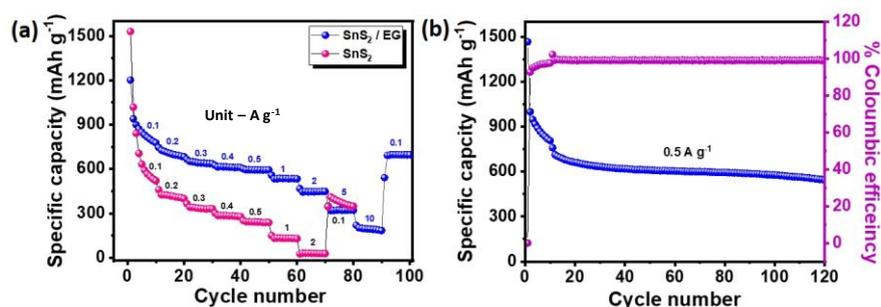


Figure 1: (a) rate capability of SnS₂ and SnS₂/EG and (b) stability analysis of SnS₂/EG