Porous SiO_X/C sphere composite as advanced anode materials for high performance lithium-ion batteries

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Abstract

As the demand for lithium-ion batteries (LIBs) rises in applications such as electronic devices, robotics, and electric vehicles, the need for improved capacity, cycle stability, rate capability, and safety has become increasingly critical. Silicon-based SiO_x anode materials are promising candidates for next-generation LIB anodes to replace graphite, owing to their high theoretical storage capacity, appropriate delithiation potential, low production cost, and eco-friendly characteristics. However, the practical application of SiO_x anode materials has been significantly constrained by several challenges, including substantial volume expansion during lithiation/delithiation, continuous formation of the solid electrolyte interphase (SEI), and poor electrical conductivity. To address these issues, the rational design of SiO_x with carbon composites has been extensively investigated.

In this study, SiO_x/C composites were fabricated using a sol-gel method. Vinyltriethoxysilane and resorcinol/formaldehyde were selected as the silicon and carbon precursors, respectively, to synthesize uniform spherical porous SiO_x/C composites. Due to the strong chemical bonds between Si-O-C, the amorphous SiOx particles are uniformly dispersed within the carbon matrix, forming a monodisperse microbead architecture with excellent buffering properties. As a result, the SiO_x/C anode demonstrates outstanding electrochemical performance. Specifically, it maintained a reversible capacity of 974 mAh g^{-1} at 0.5 A g^{-1} after 300 cycles and 736 mAh g^{-1} at 2 A g^{-1} after 400 cycles, exhibiting excellent cycling stability. Moreover, after 50 charge-discharge cycles, the electrode's volume increased by only 47%, effectively mitigating the issue of volume expansion.

***Key words**: Silane coupling agents, Silicon suboxide, Lithium-ion batteries, Anode*