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Development of SiO_2-Based Anode Material from Sri Lankan Vein Quartz for Rechargeable Lithium-Ion Batteries

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Abstract

The search for sustainable anode materials for rechargeable lithium-ion batteries has prompted the investigation of silicon oxide-based materials as promising alternatives. In this study, high-purity Sri Lankan Vein Quartz (SLVQ) was mechanically milled and combined with conductive additives and binders to fabricate an anode electrode. The milled samples were characterized using X-Ray Fluorescence (XRF), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), and X-Ray Diffraction (XRD). Electrochemical performance was evaluated through half-cell testing methods, including Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS), and galvanostatic cycling. Characterization results confirmed the presence of high-purity quartz with minimal impurities. Electrochemical analyses revealed stable lithium insertion and extraction, with distinct redox peaks at 0.55 V and 2.10 V, respectively. Although the material exhibited relatively high charge transfer resistance, likely due to its inherently low electrical conductivity, it demonstrated excellent cycling stability and maintained consistent specific capacity with 99% Coulombic efficiency over multiple cycles. These findings highlight the potential of SLVQ, when properly processed, to serve as a cost-effective and environmentally friendly alternative to synthetic silicon oxide-based anode materials.