Enhancing scalability and sustainability of next-gen LIBs anode through optimized dual-binder design

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The rapid advancement of lithium-ion batteries (LIBs) has been driven by academic research and industrial investment in recent years. However, achieving greater sustainability in LIB production requires addressing critical challenges, such as reducing environmental impact and replacing toxic and critical raw materials [1,2]. This study explores improvements in the production process of SiO_x/C anode electrodes for next-generation LIBs by identifying water-compatible binders that ensure robust mechanical and electrochemical properties. The principal aim is to provide a sustainable and cost-effective alternative to the conventional PVdF/NMP (polyvinylidene fluoride/N-methyl pyrrolidone) system and a more versatile substitute for the Na-CMC/SBR (sodium carboxymethyl cellulose/styrene-butadiene rubber) binder combination.

A comprehensive screening of water-soluble binders, primarily polysaccharides, was conducted to evaluate their rheological, chemical, and electrochemical properties. The most promising binder was successively combined with lithium polyacrylate (LiPAA) in various weight ratios to investigate potential synergistic effects on electrode performance. Experimental results identified the optimal weight ratio of 66:33 (LiPAA : sodium alginate) as delivering superior performance in terms of specific capacity, coulombic efficiency, and capacity retention, with internal resistance decreasing over cycling. Statistical analysis confirmed the significant influence of binder composition on electrode performance. The results highlight the potential of natural-synthetic binder combinations to balance mechanical integrity, sustainability, and electrochemical efficiency, offering valuable insights for the development of next-generation LIB anodes.

Keywords: *Li-ion battery, electrode manufacturing, binder, SiO_x/C anode, sodium alginate, LiPAA*

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