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Rapid Selective Recycling of Spent $LiFePO_4$ Cathodes via a Deep Eutectic Solvent-Assisted Carbothermal Shock Method

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ABSTRACT

The surge in lithium-ion battery adoption has underscored the critical need for innovative recycling technologies, particularly for lithium iron phosphate ($LiFePO_4$, LFP) cathodes, which dominate the market due to their safety and cost advantages. However, the thermally stable olivine structure of LFP presents formidable challenges for conventional pyrometallurgical recycling, resulting in excessive energy consumption to break down the LFP structure, substantial lithium loss, and diminished economic viability. Herein, we introduce a carbothermal shock process, synergistically enhanced by deep eutectic solvents composed of choline chloride (ChCl) and urea, to address these limitations. This ultrafast approach (~20 s) overcomes the issue of insufficient contact in solid-solid reactions through the complete encapsulation of spent LFP by ChCl, effectively preventing Li volatilization during the short reaction time. The process yields high-purity Fe_2P and Li_3PO_4, which are efficiently separated using magnetic methods, achieving high recovery efficiencies of Li (97.39%) and Fe (99.17%). Notably, the recovered Fe_2P demonstrates enhanced catalytic performance in the alcoholysis of waste polyethylene terephthalate plastics, creating a synergistic valorization pathway. This effective method not only eliminates complex separation processes but also advances the circular economy, enabling high-value resource recovery for the lithium-ion battery ecosystem.

KEY WORDS

Carbothermal shock; Selective recycling; Deep eutectic solvents; $LiFePO_4$ cathode; Lithium-ion batteries

BIOGRAPHY

Xuhui Zhu is a PhD candidate in the Department of Chemical Engineering at the University of Melbourne, supervised by Dr. Helena Wang in the Renewable Resources & Sustainability (R^2S) group. She obtained her Master's degree from Jiangsu Normal University in 2024, where she conducted research under the supervision of Prof. Shun Yang. Her current research focuses on the recycling and regeneration of cathode materials from spent lithium-ion batteries, including the application of deep eutectic solvents and rapid thermal processes.

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