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Green Recycling of Spent Lithium-Ion Battery Waste for Recovery of Valuable Metals Using Deep Eutectic Solvents (DES)

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ABSTRACT

The rapid growth in the production and use of lithium-ion batteries, driven by the increasing demand for electric vehicles, portable electronics, and renewable energy storage systems, has created a significant challenge in the management of end-of-life battery waste. Spent lithium-ion batteries contain considerable quantities of valuable metals such as lithium, nickel, manganese, cobalt and iron which are critical for the manufacturing of new battery materials. The recovery of these metals through effective recycling strategies is essential to reduce dependence on mining, mitigate environmental impacts, and support the development of a sustainable circular economy for energy storage technologies.

Hydrometallurgical processing of battery waste focuses on recovering valuable metals with high efficiency and lower energy consumption compared with traditional high-temperature processing routes. To avoid using hard mineral acids and corrosives for leaching, deep eutectic solvents (DES) have recently emerged as promising alternatives for metal extraction applications. Due to their low volatility and high selectivity towards metals, DES systems are employed for specific separation and extraction processes. However, there is a lack of clear understanding of reaction mechanism and kinetics of DES recovery of critical metals from spent cathode powder (black mass).

This study focuses on the potential use of deep eutectic solvent systems for the recovery of valuable metals from spent lithium-ion battery materials. Experimental investigations include developing a mechanism scheme and kinetic model of leaching of lithium, nickel, manganese, cobalt from black mass. The work aims to assess the kinetics of DES-based processes for selective metal recovery for better understanding of the interactions between solvent systems and battery materials during the extraction process.

KEY WORDS

Lithium-ion batteries, end-of-life battery waste, deep eutectic solvents; circular economy

BIOGRAPHY

Mahaveer Bilkhu is a PhD candidate in the School of Chemical Engineering at Adelaide University and has graduated from the University of Adelaide with a Masters degree in Chemical Engineering. His current research focuses on investigating and optimising hydrometallurgical processes for the sustainable recycling of lithium-ion batteries and improving critical metal recovery from mixed battery waste streams. His previous work included the development of a digital twin for the mashing process in brewing, focusing on modelling and optimisation for Waite microbrewery at the University of Adelaide. His research interests include process modelling, reaction kinetics, and sustainable resource recovery.

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