Selective Recovery of Critical Metals from Spent Lithium-Ion Batteries Using Deep Eutectic Solvents

Ayse Yaren Ozkan
Istanbul Technical University, Turkey

Vedat Uyak
Istanbul Technical University, Turkey

Abstract

The increasing demand for electric vehicles (EVs) and portable electronic devices has significantly boosted the consumption of lithium-ion batteries (LIBs), highlighting the urgent need for sustainable and resource-efficient recycling technologies. In this context, the recovery of critical metals such as lithium (Li), cobalt (Co), nickel (Ni), and manganese (Mn) from spent LIBs has become a strategic priority for circular economy and resource security. Although conventional recycling methods like pyrometallurgy and hydrometallurgy are commonly used, they are often associated with high energy consumption, toxic reagents, and environmental harm. However, green alternatives such as deep eutectic solvents (DESs) and ionic liquids (ILs) offer environmentally friendly and selective alternatives for metal extraction.

This study proposes an innovative and eco-efficient DES system based on choline chloride (ChCl) for the selective recovery of Co, Ni, Mn, and Li from black mass obtained from spent LIBs. Due to the similar chemical behaviour of these metals, selective separation is challenging. However, the proposed process enables high-purity metal salt recovery through a controlled solvent extraction route. Key operational parameters, including pH, solid-to-liquid ratio, and extraction time, were systematically optimized to maximize efficiency. Additionally, the reusability of the DES was evaluated to enhance cost-effectiveness.

The results demonstrate that green solvent-based systems can achieve not only high metal recovery and selectivity but also minimize environmental impact and operational costs. These findings position the developed process as a promising and industrial-scale solution for sustainable LIB recycling applications.

Keywords

Lithium-ion battery recycling, solvent extraction, deep eutectic solvents, critical raw materials, circular economy.