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Enhanced dissolution of valuable metal oxides from spent lithium-ion batteries in sustainable alcohol-based solvents

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PURPOSE OF THE ABSTRACT

The growing electrification of society relies on electronic devices and energy storage devices, especially lithium-ion batteries (LIBs). Ever since their first commercialization, properties such as high energy density and capacity, good cycle life and low maintenance rendered them a staple in the energy sector. Thus, the demand for LIBs is projected to rise 14-fold by 2030 (1), and consequently, the demand for valuable metals, such as lithium, cobalt, nickel and manganese. Spent LIBs are interesting sources of these critical raw materials, due to high purity grade of the elements in these matrices when compared to mineral ores (2).

Conventional spent LIB recycling methods, pyro- and hydrometallurgy, have disadvantages that could be suppressed with novel approaches. Solvometallurgy, using non-aqueous systems, such as deep eutectic solvents (DESs), can be used for more selective metal dissolution and mitigate the amount of hazardous effluents (3). Apart from their low cost and benign biodegradability, their components can act as chelating, reducing and extracting agents, potentially increasing the atom efficiency of the recycling process (4). Furthermore, as ?tunable' solvents, these can be adapted to allow for selective recovery of metals (3). Nonetheless, DESs have some caveats which require further understanding when comparing their efficiency with simpler leaching systems. For example, the proton activity of acids in non-aqueous systems is lower than in aqueous ones, theoretically reducing the acid leaching efficiency (5). Their reusability over several leaching cycles is also hindered by typical leaching conditions (e.g. temperature) causing chemical modifications on the DESs (6).

In this work, the contribution of each DES constituent towards the leaching of nickel, cobalt and manganese oxides, namely the hydrogen bond donor selection, acid type and concentration and halide source were systematically evaluated.
Leaching results indicate that enhanced cobalt oxide dissolution was obtained in alcohol solutions with small quantities of HCl relative to that in equivalent aqueous solutions or in DES with carboxylic acids. The acid concentration effect on the dissolution of cobalt was enhanced in the alcohols. For chlorophilic metals such as cobalt this could be explained by the increased chloride activity in alcohol media. Negligible nickel oxide was dissolved in all systems, resulting in the enhanced enrichment factor of cobalt from mixed oxides matrices such as NMC type LIBs. Thus, depending on the step in the overall LIB recycling process, the use of these alcohol systems could be more cost- and atom efficient than DES.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

battery recycling | deep eutectic solvents | metal recovery | cobalt

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