RE-THINKING SPENT $LiFePO_4$ CATHODES RECYCLING

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Abstract

With the advantages of high safety, enhanced cycling stability, low cost and reduced toxicity, lithium iron phosphate (LFP) is becoming the preferred among available Li-ion batteries chemistries and is set to be prominent on the market in the next years. This trend will eventually result in a huge retirement wave that, if poorly managed, will cause serious environmental damage as well as the loss of valuable resources. Indeed, recovering metals from spent LFP cathodes is crucial as they contain, in percentage, more lithium than the ore from which it is extracted. Hydrometallurgical techniques are the preferred ones for spent LFP treatment. So far, metal leaching has been performed with strong inorganic acids, which, in addition to being toxic and harmful to the environment, require the use of expensive equipment to withstand the harsh processing conditions. Furthermore, selective lithium solubilization has been achieved using strong oxidants such as H_2O_2 and NaClO.

In this study, selective lithium recovery from LFP powders was achieved combining the action of malic acid and oxygen from air, in a reaction mimicking the battery charge process.

Malic acid, an organic H^+ donor, was chosen as it offers several advantages such as biocompatibility, mild operating conditions and facile downstream recovery. Oxygen coming from air, on the other hand, was individuated as a free and ecofriendly alternative to the previously mentioned oxidants.

A fed-batch reactor, with continuous air bubbling and controlled acid feeding has been set up and single factor experiments were carried out to optimize process conditions, with the aim of maximizing both leaching efficiency and selectivity.

The following techniques were used to characterize raw materials and reaction products to determine the extent of metal solubilization and to investigate possible reaction mechanisms: inductively coupled plasma-mass spectroscopy (ICP-MS), X-ray diffraction (XRD), X-ray fluorescence spectrometry (XRF), and Fourier transform infrared spectroscopy (FT-IR).

The outcomes of the study demonstrate the viability of the proposed process, which is capable of extracting more than 90% Li while keeping Fe and P leaching efficiency as low as 10%.

This strategy appears as a cheap and green alternative to conventional hydrometallurgy and opens up the possibility of using waste biomasses as precursors for ecological lixiviants, a topic that is currently under investigation in our laboratory.