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Sustainable technologies for the extraction and separation of strategic raw materials for lithium-ion batteries: an innovative development.

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The transportation sector is critical to the global economy, but it is also a major source of greenhouse gas emissions and air pollution. To address these challenges, electric vehicles (EVs) are emerging as a promising solution, backed by lithium-ion batteries (LIBs) due to their efficiency and low self-discharge. The number of EVs on the road is expected to increase significantly by 2030, requiring an expansion in battery production, regulated by sustainability regulations such as EU Regulation 2023/1542. However, the extraction of raw materials for these batteries faces ethical and supply challenges, with lithium sourced mainly from Australia, Chile, China and Argentina, and cobalt from the Democratic Republic of Congo, with questionable labor conditions. In addition, uncertainty in nickel supply poses additional challenges due to geopolitical conflicts. As the recycling of LIBs becomes crucial, the European Union is setting ambitious targets for the recycling of key materials such as cobalt, nickel and lithium by 2031.

Initially, a rigorous evaluation of the state of the art was performed in order to analyze the different stages of discharge, pretreatment, leaching and extraction of valuable materials involved in the separation and recovery process. The potential extraction of four target metals from LIBs according to the literature (Ni^{2+}, Co^{2+}, Li^{+} and Mn^{2+}) has been theroretically confirmed tunsing conventional extractants such as Di(2-ethylhexyl)phosphoric acid (D2EHPA) and Diiso-octylphosphoric acid (Cyanex 272). The goodness of the predictions has been evaluated by obtaining their extraction isotherms with the D2EHPA extractant, capable of extracting Ni^{2+}, Co^{2+} and Mn^{2+} at different pH values. The evaluation focused on the separation of Co^{2+} and Mn^{2+} at acid pH values (pH=3), reaching high extraction values in the case of Mn^{2+}.

These promising results support the development of solvent extraction-based technologies for the recovery of valuable materials from spent LIBs, promoting the circular economy, and decreasing depletion of natural resources used in the manufacture of new LIBs.

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