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Low-carbon Footprint Diluents in Solvent Extraction for Lithium-ion Battery Recycling

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Abstract : Lithium-ion battery (LiB) is the technology of choice in the development of electric vehicles. But there are still many challenges, including the development of positive electrode materials exhibiting high cycle ability, high energy density, and low environmental impact. For this latter, LiBs must be manufactured in a circular approach by developing the appropriate strategies to reuse and recycle them. Presently, the recycling of LiBs is carried out by the pyrometallurgical route, but more and more processes implement or will implement the hydrometallurgical route or a combination of pyrometallurgical and hydrometallurgical operations. After producing the black mass by mineral processing, the hydrometallurgical process consists in leaching the black mass in order to uptake the metals contained in the cathodic material. Then, these metals are extracted selectively by liquid-liquid extraction, solid-liquid extraction, and/or precipitation stages. However, liquid-liquid extraction combined with precipitation/crystallization steps is the most implemented operation in the LiB recycling process to selectively extract copper, aluminum, cobalt, nickel, manganese, and lithium from the leaching solution and precipitate these metals as high-grade sulfate or carbonate salts. Liquid-liquid extraction consists in contacting an organic solvent and an aqueous feed solution containing several metals, including the targeted metal(s) to extract. The organic phase is non-miscible with the aqueous phase. It is composed of an extractant to extract the target metals and a diluent, which is usually aliphatic kerosene produced from the petroleum industry. Sometimes, a phase modifier is added in the formulation of the extraction solvent to avoid the third phase formation. The extraction properties of the diluent do not depend only on the chemical structure of the extractant, but it may also depend on the nature of the diluent. Indeed, the interactions between the diluent can influence more or less the interactions between extractant molecules besides the extractant-diluent interactions. Only a few studies in the literature addressed the influence of the diluent on the extraction properties, while many studies focused on the effect of the extractants. Recently, new low-carbon footprint aliphatic diluents were produced by catalytic dearomatisation and distillation of bio-based oil. This study aims at investigating the influence of the nature of the diluent on the extraction properties of three extractants towards cobalt, nickel, manganese, copper, aluminum, and lithium: Cyanex®272 for nickel-cobalt separation, DEHPA for manganese extraction, and Acorga M5640 for copper extraction. The diluents used in the formulation of the extraction solvents are (i) low-odor aliphatic kerosene produced from the petroleum industry (ELIXORE 180, ELIXORE 230, ELIXORE 205, and ISANE IP 175) and (ii) bio-sourced aliphatic diluents (DEV 2138, DEV 2139, DEV 1763, DEV 2160, DEV 2161 and DEV 2063). After discussing the effect of the diluents on the extraction properties, this conference will address the development of a low carbon footprint process based on the use of the best bio-sourced diluent for the production of high-grade cobalt sulfate, nickel sulfate, manganese sulfate, and lithium carbonate, as well as metal copper.

Keywords : diluent, hydrometallurgy, lithium-ion battery, recycling
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