Recovery of critical metals from spent Li-ion batteries: Sequential leaching, precipitation, and cobalt-nickel separation using Cyphos IL104

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Abstract

This study presents a novel recycling scheme for spent Li-ion batteries that involves the leaching of lithium in hot water followed by the dissolution of all transition metals in HCl solution and their separation using the ionic liquid Cyphos IL104. The parametric studies revealed that >84 % Li was dissolved while the cathode material was leached at 90 degrees C for 2 h. Approximately 98 % Li from the non-acidic solution was directly precipitated as Li2CO3 at a Li+:CO32- ratio of 1:1.5. The transition metals from the Li-depleted cathode mass were efficiently (>98 %) dissolved in 3.0 mol.L-1 HCl at 90 degrees C for a 3 h leaching process. Manganese from the chloride leach liquor was selectively precipitated by adding KMnO4 at a 1.25-fold higher quantity than the stoichiometric ratio, pH value 2.0, and temperature 80 degrees C. The remaining co-existing metals (Ni and Co) were separated from the chloride solution by contacting it with a phosphonium-based ionic liquid at an equilibrium pH value of 5.4 and an organic-to-aqueous phase ratio of 2/3. The loaded ionic liquid was quantitatively stripped in 2.0 mol.L-1 H2SO4 solution, which yielded high-purity CoSO4 center dot xH(2)O crystals after evaporation of the stripped liquor. Subsequently, similar to 99 % nickel was recovered as nickel carbonate [NiCO3 center dot 2Ni(OH)(2)] from the Co-depleted raffinate by the precipitation performed at Ni2+:CO32- ratio of 1:2.5, pH value of 10.8, and temperature of 50 degrees C. Finally, a process flow with mass and energy balances yielding a high recovery rate of all metals in the exhausted cathode powder of spent LiBs was proposed.

Keywords

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