The role of electrified hydrometallurgical unit processes in Li-battery recycling

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Li-battery recycling can be conducted either by pyro-hydrometallurgical or solely hydrometallurgical refining routes. Hydrometallurgical processing includes extraction and purification in aqueous media, with a typical flowsheet consisting of leaching, neutralization, separation, solution purification, and metal recovery unit processes, as well as lixiviant recirculation. Most of the unit processes have traditionally been chemically driven, including the use of acids (leaching), alkaline chemicals (neutralization), organic chemicals (extractants, diluents, modifiers in solvent extraction), precipitation agents (impurity removal, metal recovery, wastewater purification) as well as ion exchange resins when applicable. However, electrified unit processes have been stated as one of the twelve principles of circular hydrometallurgy, as they may provide competitivity in several aspects of sustainability, when coupled with use of low-carbon electricity.

In battery recycling, the most typically suggested electrometallurgical process is electrowinning i.e. recovery of solid metal on cathode from highly purified solutions (after solvent extraction), while generating oxygen at the anode. However, interest in alternative electrified operations has recently grown, and several novel technologies as well as process flowsheets are emerging. Examples include direct electrowinning, anodic methods, synergistic cathodic–anodic recovery routes, pulsed methods as well as electrically driven lixiviant circulation. In electrified processes, chemical consumption decreases as a trade-off for electricity. Potentially, also waste generation may be decreased when e.g. Na_2SO_4 generation is avoided. Consequently, electrification—together with both incremental and disruptive process innovations, as well as digitalization—has potential to accelerate the decarbonization of battery industry.

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