Advancing Critical Materials Recovery via Biobased Recovery Processes

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The demand for critical minerals and materials (CMMs) is anticipated to rise further with decarbonization of industry and transportation sectors. With rising demand, dwindling natural reserves, and significant supply risks, it is critical to harvest CMMs not only from the primary resources (e.g., ore deposits), but especially the secondary resources from the domestic waste streams (e.g., e-scrap, black mass from recycled batteries, mining waste, processed water, and manufacturing scrap). Biohydrometallurgy processes are emerging technologies and present promising avenues toward establishing sustainable and economically viable methods for separating, recovering, and concentrating critical materials from the recycled batteries and e-scraps. Bioleaching is the first step in biohydrometallurgy where microbial activity facilitates the solubilization of CMMs.

Argonne's novel arrested methanogenesis technology (US Patent No: 12,151,959) produced high-titer organic acids and microbial exudates as biolixiviant. Important factors affecting the CMMs leaching from black mass including pH, operating temperature, solid/liquid ratio (pulp density), and reactor residence time were tested to determine the operating conditions to achieve higher extraction efficiency of CMMs than that of the reported in the literature. An in-depth analysis of experimental data was performed to characterize the key performance indicators across a range of CMMs concentrations and profiles to scale up the new bioleaching process. Our results demonstrated the development of a new eco-friendly bioleaching process, achieving over 90% recovery of critical metals like cobalt and lithium from spent batteries.