Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23088

Novel, economically sustainable, and environmentally friendly extraction of Lithium from alternate brine sources using Direct Lithium Extraction

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The demand for Lithium (Li) is projected to increase exponentially in the next decade, making it a critical element that is susceptible to supply chain disruptions. Emerging Direct Lithium Extraction (DLE) technologies have the potential to expand the Li resource base, as low Li grade oil-field brines are among the most promising potential Li-bearing water (LBW) sources. Ion-exchange type DLE (i-DLE) materials have proven to be most effective in extracting Li because they have far lower freshwater use than conventional mining. The rapid extraction rates and high Li uptake capacities of i-DLE adsorbents make i-DLE scalable. However, DLE projects in the U.S. and Canada are hindered by the constraint on the economics of development projects, life cycle analyses of the i-DLE adsorbents, and compounds detrimental to i-DLE sorbents that are found in LBWs. Some sources of LBWs, including oil-field brines, can contain dissolved organic compounds and H_2S which are strong reducing agents that can lead to sorbent fouling and degradation. With manganese spinel type i-DLE adsorbents being the most commonly studied and tested, further research into the process economics in terms of recyclability/longevity of the adsorbent is required. In this study, we tested a lithium manganese oxide (LMO) i-DLE sorbent that is coated with 7.5 nm of zirconium dioxide to inhibit contact between reducing agents in the brine and the sorbent surface. Results show that in a field-collected oil-field brine containing organic compounds and trace H_2S, the Li uptake was 24 mg g^{-1} in 1 h. Embedding the i-DLE sorbent into a polyvinylidene fluoride (PVDF) vesicular binder preserved the surface area of the nanoparticulate aggregate of LMO, achieving a Li uptake of 20 mg g^{-1} in 6 h. Furthermore, the Mn loss per cycle, which is as high as 4.5% in the unmodified sorbent, was reduced by 50% using the 7.5 nm zirconium coating and by 90% using the PVDF binder. X-ray absorption spectroscopy confirms no structural change in the LMO after 16 cycles, showing a theoretical recyclability of 100 cycles. The small footprint and rapid extraction kinetics make i-DLE technology suitable for rapid expansion of Li production from LBWs.