Engineered Lithium-Ion Sieve Technology (E-LIST) for Direct Lithium Extraction and Lithium Hydroxide Production

Lithium (Li) is considered a Critical Material by the US Department of Interior due to its significance for meeting future energy demands since the domestic production of Li to facilitate self-reliance is essential to the national interest. The demand for Li is expected to grow up to 0.84 – 105 Mt in 2100 and this projected demand for lithium and aims to transform towards a more sustainable future necessitates the exploration of new domestic resources, and development of new extraction technologies. Further, the contribution of geothermal energy to electricity generation in the US is expected to quadruple by 2040, and these geothermal sources offer a growing potential for contributing to domestic Li supply security. Li recovered from such domestic geothermal brines could potentially accommodate from 4%-8% of domestic demand. The extraction of Li from geothermal brines is attractive because it uses produced brine - after power generation - and can make use of existing facilities to lower production and capital costs. In the US, the Salton Sea field in California is one of the most mineral-rich geothermal brine sources, with the most geothermal plants in the region. Coupling geothermal energy production with mineral recovery is an attractive approach for a sustainable and competitive future energy-mineral landscape. Our team has developed a robust approach utilizing **E**ngineered **L**ithium-**I**on **S**ieve **T**echnology (E-LIST) to facilitate Li adsorption from brine chemistries via an endothermic (entropically driven) pathway, and thus the adsorption performance, i.e., capacity and selectivity, increases with fluid temperature. Separation of Li through these sieves is size dependent, therefore, higher separation of Li is noted from larger ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, and Cs^+), which are commonly present in brines. Moreover, dehydration enthalpy of Li^+ ions is significantly lower than Mg^{2+} ions, thus using these engineered sieves for separation yield higher Li^+/Mg^{2+} ratios. Using these sieves also avoids the evaporation-based concentration steps, saving weeks' worth of time and other resources. In our technology, we use Ti-based layered ionic sieves (Li_2TiO_3), which offer higher adsorption capacity (5-40 mg/g) and are stable in acidic environments representative of Salton Sea brines, offering the advantage of wider operational conditions. After the selective adsorption of Li in sieve materials, the adsorbed Li is recovered using dilute acidic solutions and then passed to an electrodialysis cell to produce battery-grade LiOH without the intermediate production of Li_2CO_3. We use the electrodialysis approach to produce LiOH since it offers high purity product and avoids any remnant Mg^{2+} carryover in the final product. Further, during this step, H_2 gas and acid are produced as by-products. H_2 can be used as an energy carrier for Li extraction, and the acid is recycled back to the elution step. Besides these circular economic benefits, this approach can harness inexpensive industrial residues (e.g., titanium slag) to engineer sieves thereby reducing the sorbent material's manufacturing costs.