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The effect of interlayer chemistry of Li/Al layered double hydroxides on lithium recovery from brines in direct lithium extraction technology

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With the development of mobile devices and electric vehicles, the demand for lithium is growing. Most of the world's lithium resources (59%) are found in continental brines rather than hard rock [1]. Conventional lithium extraction from brines via evaporation is time-consuming, land-intensive, and raises environmental concerns, driving interest in direct lithium extraction (DLE) using adsorbents for selective lithium recovery.

This study investigated the impact of interlayer modification of Li/Al layered double hydroxides (LDHs) with Cl^- , NO_3^-, SO_4^{2-}, and PO_4^{3-} on their efficiency, selectivity, and stability for lithium recovery. Li/Al-LDHs (Li:Al 1:2) were synthesized via coprecipitation. Following solid-state characterization, the materials were evaluated in both LiCl solution and simulated brine, with adsorbent dosage 10 g/L and Li^+ concentrations 200 mg/L (adsorption) and 25 mg/L (desorption).

In simulated brine, all materials exhibited enhanced Li adsorption (by an average factor of 1.4) compared to pure LiCl solution, with the Li/Al-LDH-Cl achieving the highest capacity (5.85 mg/g). The increase in Li desorption induced by $LiCl_{aq}$ versus brine was anion dependent. The Cl- and NO_3-intercalated LDHs demonstrated a moderate increase in desorption (1.6–1.7 fold) in brine: 2.93 mg/g and 2.27 mg/g, respectively. For the SO_4-intercalated LDH, the increase was 9-fold, yielding 2.79 mg/g in brine. The PO_4-intercalated LDH showed a 6-fold increase, but its desorption in brine reached only 0.59 mg/g. The materials exhibited high selectivity coefficients for Li^+ over Na^+, K^+, Ca^{2+}, and Mg^{2+}, ranging from 30 to 60, except for the PO_4-intercalated LDH (~10).

Intercalation with Cl^-, NO_3^-, and SO_4^{2-} yielded Li/Al-LDHs with high adsorption capacities and selectivity, positioning them as promising candidates for DLE. Notably, the SO_4^{2-}-intercalated material exhibited a strong matrix-dependent performance, with its properties being significantly enhanced in the simulated brine. This underscores the critical role of anion selection in designing efficient LDH adsorbents for specific brine compositions.

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