Nano-sized Lithium Aluminum Layered Double Hydroxides in Lithium Ion Extraction

Iulia Coultis, Viviana Cruz, Dr. Holly Stretz; Chemical Engineering

Introduction/Background

Due to rising global use of high performance batteries, lithium is in growing demand. Lithium may be classified as an energy critical element (ECE) due to its importance to clean energy and the risks associated with its supply. [1] As such, novel ways for extracting it are being pursued. Over half the planets extractable lithium is found in the geopolitically sensitive countries of Argentina, Bolivia, and Chile.
Current extraction methods center around either open-pit spodumene mining or salt-lake evaporation. Employing sorbents in brine lakes to selectively adsorb lithium ions is a developing technology in lithium recovery. The scope of this research is to asses the efficacy of nano-sized lithium aluminum layered double hydroxide chloride, Li-Al LDH, as a sorbent. High surface area LDH is synthesized from nanoparticle precursors and tested against larger synthesized particles from ORNL [2].

Research Questions

1) Can nanoparticle Layered Double Hydroxide (LDH) be synthesized?
2) Can nanoparticle LDH be removed from solution?
3) How does the lithium uptake of nanosized LDH compare to the macroscale?

Design and Methods

Synthesis of nano-sized LDH begins with nano-sized gibbsite, simplistically modeled in the following equation:

$$Al(OH)_3 + LiOH \bullet H_2O + HCl \rightarrow xLiCl \bullet 2Al(OH)_3 \bullet mH_2O$$

Characterization of chemical makeup, particle size, and topical morphology are confirmed though X-ray Diffraction (XRD), Dynamic Light Scattering (DLS), and Scanning Electron Microscope (SEM) Imaging respectively.

Extraction is performed at 95 C for 20 minutes. Before performing the extraction tests, an unloading step in necessary to remove some of the lithium ions present from synthesis. Centrifugation or nano-filtration can be employed to remove the LDH from solution.

Finally, the lithium ion content of extraction tests is analyzed through Inductively Coupled Plasma (ICP) Analysis.

Results

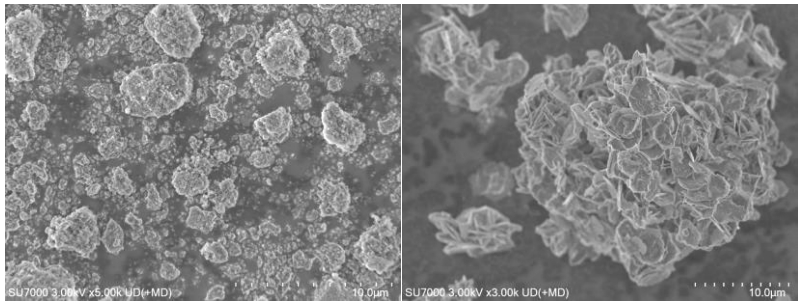

Fig. 1 SEM Images of Nano Al(OH)3 (Gibbsite) reactant vs. Sythesized Li/Al LDH

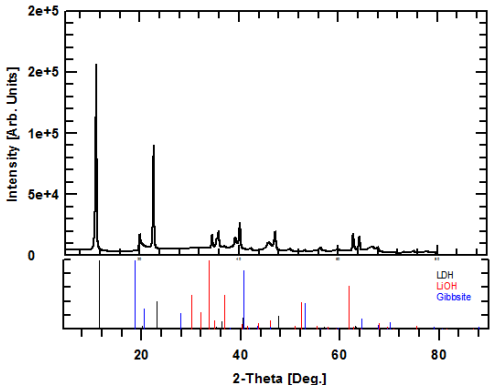

Fig. 2 XRD Graph LDH

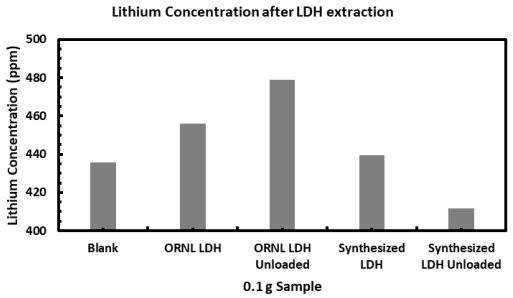

Fig. 3 ICP comparing different LDH syntheses

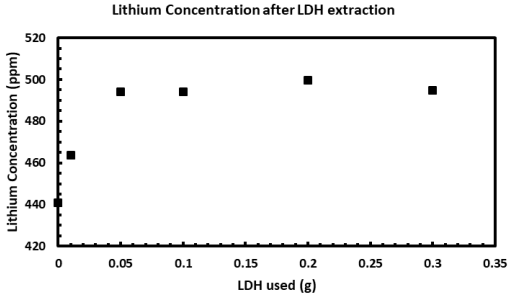

Fig. 4 ICP data of increasing LDH extraction amounts

Conclusions

Nano Li-Al LDH can be synthesized from nano gibbsite, as is confirmed by XRD, DLS, and SEM. Due to both the synthesized LDH and the sample obtained from ORNL showing small concentration changes post extraction test, further testing is required to ascertain he efficacy of the LDH as a lithium ion sorbent. Further research needs to optimize adsorption testing for the modeling of adsorption isotherms in nano-sized Li-Al LDH.

References

[1] Center for Sustainable Systems, University of Michigan. 2019. "Critical Materials Factsheet." Pub. No. CSS14-15.
[2] Mariappan Parans Paranthaman, Ling Li, Jiaqi Luo, Thomas Hoke, Huseyin Ucar, Bruce A. Moyer, and Stephen Harrison (2017). Recovery of Lithium from Geothermal Brine with Lithium–Aluminum Layered Double Hydroxide Chloride Sorbents. Environmental Science & Technology 51 (22), 13481-13486 DOI: 10.1021/acs.est.7b0346

Acknowledgments: Tessa Eskander; David Hobbs, TTU Water Center, Wayne Hawkins, Dr. Paranthaman, ORNL.