Reducing environmental impacts and improving economic prospects for lithium commodities produced with chemically integrated post-combustion capture of carbon dioxide

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Abstract:
Battery-grade lithium carbonate (Li_2CO_3 ≥ 99.5 wt%) is commonly recovered from spodumene-rich pegmatite ore by energy-intensive processes having significant environmental impacts. Upstream, ore beneficiation rejects gangue to generate spodumene concentrate, which undergoes thermal activation to convert refractory α-spodumene into its tractable β-polymorph. This high-temperature (~1100°C) calcination step contributes greatly to lifecycle greenhouse gas emissions associated with Li_2CO_3 production. Downstream, crude Li_2CO_3 is conventionally recovered by alkaline precipitation from acidic leachate, then purified via carbonation, which consumes costly, pressurized CO_2 to generate water-soluble lithium bicarbonate. The aqueous bicarbonate is separated from insoluble impurities before depressurizing to recrystallize battery-grade Li_2CO_3. A novel carbonation process variant was recently reported whereby combustion exhaust gas, such as that generated during thermal activation of spodumene concentrate, was compressed and utilized to purify crude Li_2CO_3 while about one-third of utilized CO_2 was captured from the exhaust in high purity. Thus, the novel purification process co-generated—rather than depended upon—a source of pure CO_2.[1] The effects of novel process operating conditions on recoveries and purities of battery-grade Li_2CO_3 and captured CO_2 are explored using bench- and pilot-scale testing systems to inform operating parameter ranges within upscaled models that enable predictive comparisons of techno-economic performance for conventional *versus* novel production processes. Techno-economic analysis predicts that co-generation of pure CO_2, and avoided consumption thereof, under current market conditions, substantially improves the novel scenario's net annual profit and accumulated profit over an operating plant lifetime. Also explored is the prospect of chemically integrating CO_2 capture with electrolytic processes needed for reagent-free recovery of lithium hydroxide and carbonate commodities from lithium chloride-enriched oilfield brines being generated throughout Alberta. This work demonstrates strong, long-term economic incentive for chemically integrated post-combustion capture of CO_2 from exhaust otherwise unutilized during production of valuable, lithium-based critical mineral commodities under anticipated ranges of operating and market conditions.

Figure 1. Recovery of battery-grade Li_2CO_3 from ore featuring chemically integrated capture of CO_2.[2]

Presenter:

Dr. Lindsay Hounjet is a Research Scientist with Natural Resources Canada operating out of CanmetENERGY in Devon, Alberta. He received a BSc in chemistry from the University of Saskatchewan in 2006, a PhD in inorganic chemistry from the University of Alberta in 2011, and undertook post-doctoral research in metal-free, small-molecule activation and catalysis at the University of Toronto until 2013. In 2014, Dr. Hounjet joined Natural Resources Canada, where he began investigating impacts of crude oil spills on aquatic systems. He contributed to the development of federal policies and regulations that ensure safe and effective crude oil transportation and spill response. He improved technology needed to better utilize renewable energy resources by strengthening the applicability of emerging sodium-ion batteries within stationary energy storage systems. He spearheaded innovative research projects that bolster economic incentive for capturing carbon dioxide from combustion exhaust to help achieve federal emissions targets. He actively develops innovative technologies that generate valuable critical mineral commodities from abundant resources, providing a competitive edge to Canada's private sector.

References:

[1] Hounjet, L. J.; Mobarok, M. H.; Bhatt, S. "Chemically integrating post-combustion capture of carbon dioxide with purification of lithium carbonate" *Separation and Purification Technology* **2025**, *375*, 133845, https://doi.org/10.1016/j.seppur.2025.133845.

[2] Hounjet, L. J. *Manuscript in preparation*.