Lithium Recovery from Discarded Lithium-ion Batteries by Electrodialysis

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Introduction

Lithium-ion batteries (LIBS) are essential for modern society and are the preferred energy storage for portable devices and electric vehicles owing to their light weight and high energy density. The average life span of LIBs is only 2 to 10 years after which the battery is discarded or recycled. While the high value critical minerals such as cobalt are frequently recovered, Lithium is often lost during the recycling process. To improve lithium recovery, we are investigating hydrometallurgical extraction and electrodialysis as a means to improve lithium recovery. Electrodialysis is a membrane-based separation process which under the influence of electric field allow to pass charged ions through semipermeable membrane. It is an environment friendly technique to recover the lithium from discarded batteries

Objectives

- ➢Quantify the amount of Lithium in different types of samples and process recovery
- ➢ To develop environment friendly and sustainable method for selective recovery of Lithium.
- ➢Reduce the environmental impact and cost for effective extraction
- ➢ Optimize the electrodialysis parameters

Materials and Methods

❖After separation of the internal battery components from the casing; materials were reduced by

1) Manual Shredding, 2) pulverization 3) and electric grinding to produce "Black Mass"

❖ The black mass was then subjected for chemical treatment to extract lithium

❖ Lithium was quantified in the aqueous and acidic extracts by ion chromatography

❖For the electrodialysis experiment, the aqueous extract solution was recirculated through an electrodialytic cell operated in the constant voltage mode (12 V) and lithium was recovered as LiOH

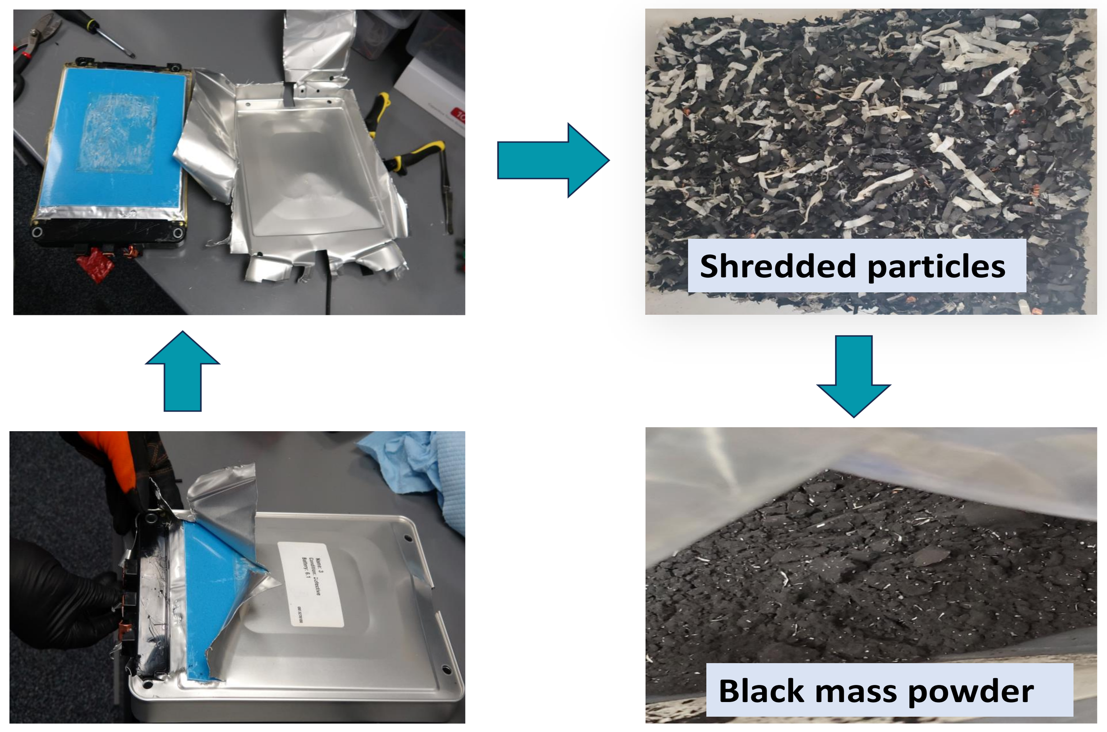

Fig 1 : Dismantlement and mechanical reduction of a lithium battery cell from an electric vehicle into black mass powder

Reduction and Extraction Results

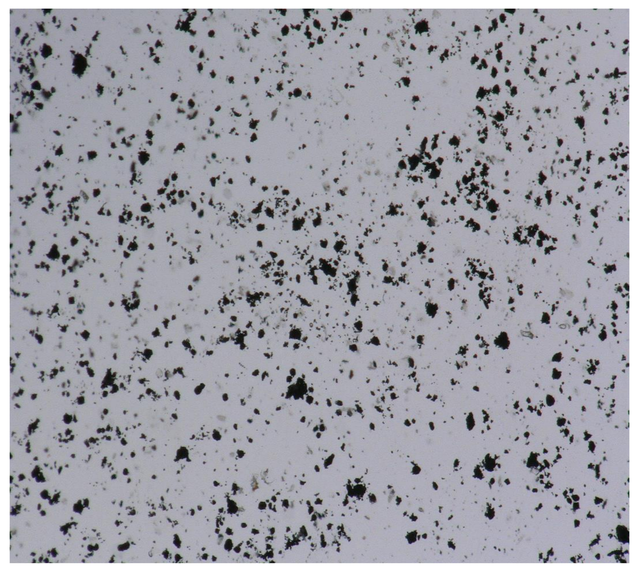

Fig 2 : Electrically ground black mass particle size measurement

Table 1 : Black mass particle characterization

	Area	Max diameter	Min diameter	Perimeter
Average	154 µm²	12 µm	7 µm	37 µm
Standard Deviation	355 µm²	16 µm	10 µm	59 µm
Max	4700 µm²	122 µm	90 µm	599 µm
Min	2 µm²	0 µm	0 µm	0 µm
Total	444176 µm²	34100 µm	20695 µm	106905 µm

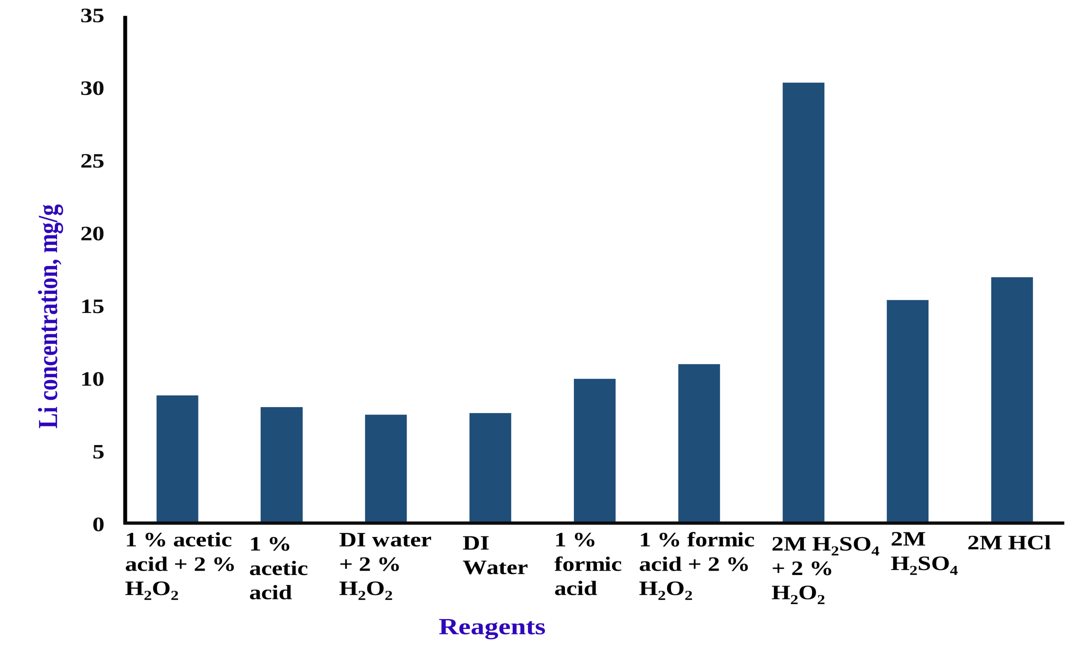

Fig 4 : Extracted lithium obtained using various chemical reagents

Fig 3 : Aqueous extract of shredded particles

Fig 5 : Acidic extract of shredded particles

Electrodialysis Setup

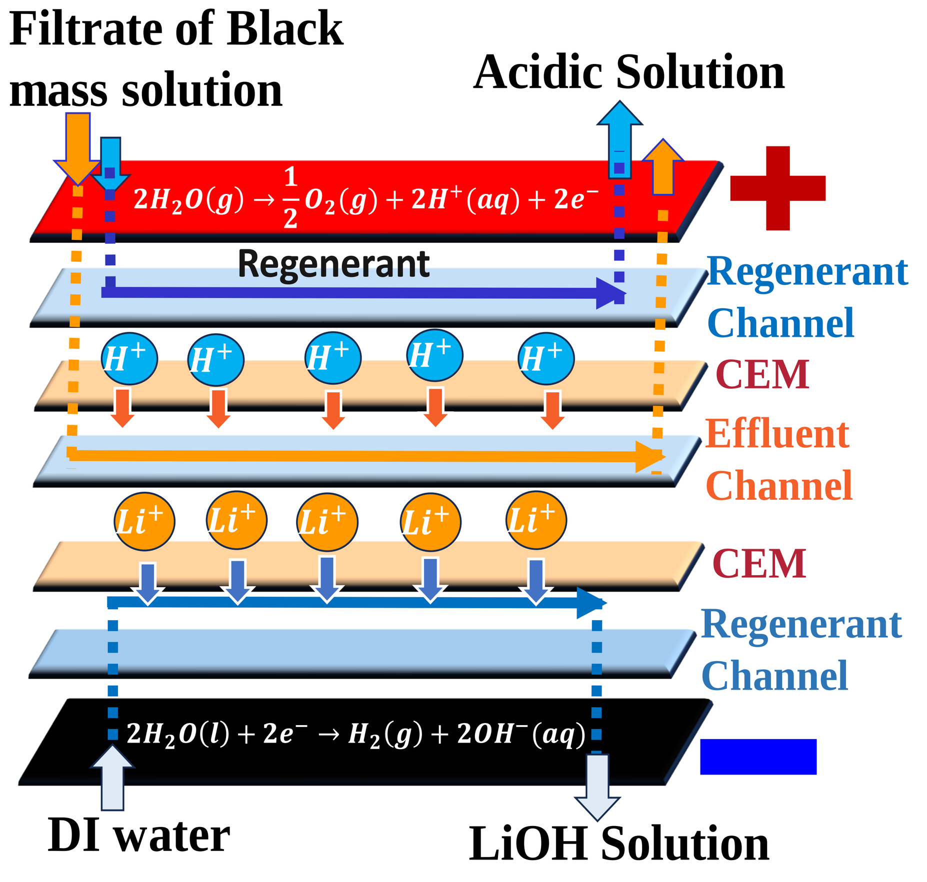

Fig 6 : Electrodialytic process for the extraction of lithium as Lithium hydroxide

The electrodialsysis cell is configured as shown in Figure 6. A peristaltic pump recirculates the extract of the black mass and deionized water separately to the donor and acceptor channels; the extract solution also serves as the electrolyte in the anode channel. Lithium is extracted through the cation exchange membrane into the cathode acceptor solution. The solutions were continuously stirred. During electrodialysis experiment, the samples were collected from each reservoir at certain time intervals and lithium amount was quantified by IC in each collected samples.

Electrodialysis Results

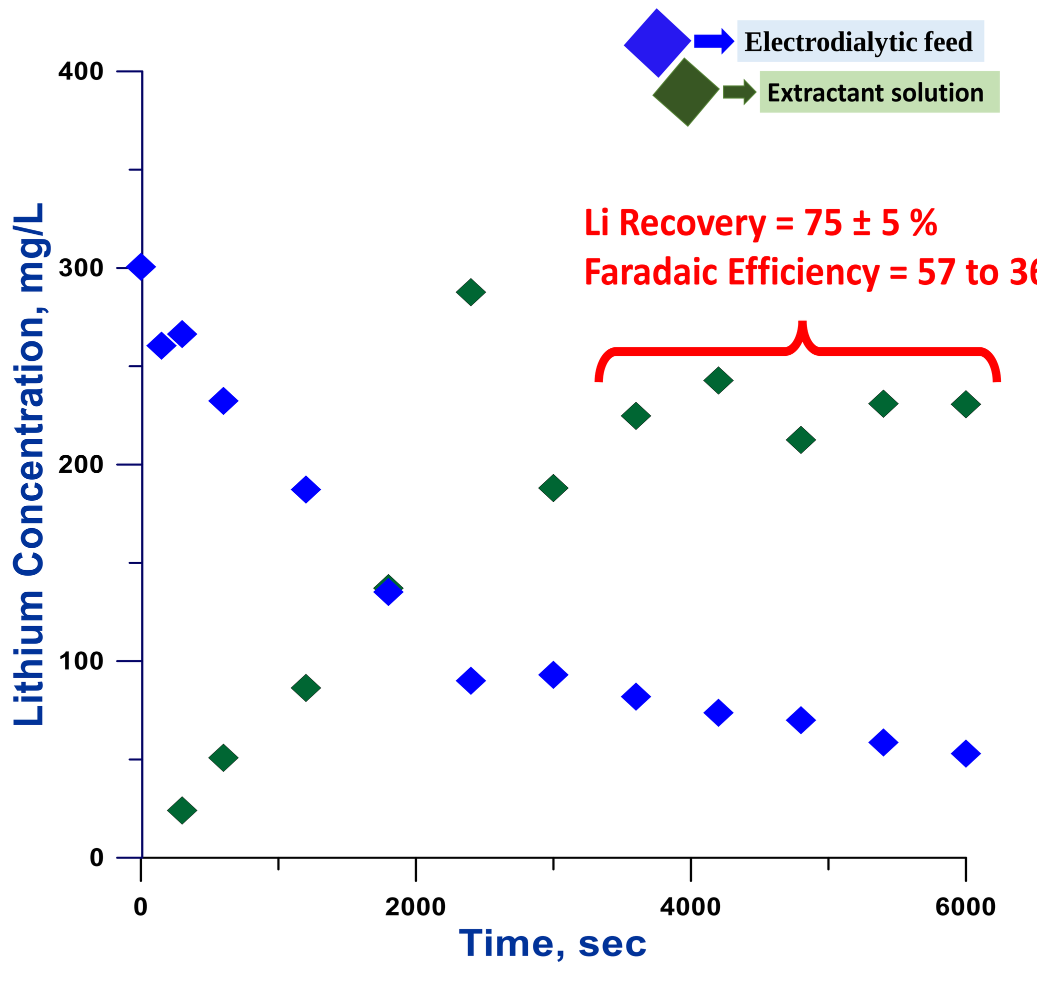

Fig 7 : Concentrations measured in electrodialytic feed and extractant solutions. The electrodialysis experiment was operated in constant voltage mode of 12 V with average current value ~ 15 mA in 10 mL of each solution.

Conclusions

❖Lithium recovery is highest at strongly acidic and oxidizing conditions

❖Lithium loss during wet crushing is expected to be ~25% of total lithium present

❖Electrodialysis using a cation exchange electrodialysis system is capable of extracting > 75% of lithium from aqueous extracts with ~60 % Faradaic efficiency.

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References

1. Song, Y., & Zhao, Z. (2018). Recovery of lithium from spent lithium-ion batteries using precipitation and electrodialysis techniques. *Separation and Purification Technology*, *206*, 335-342. https://doi.org/10.1016/j.seppur.2018.06.022
2. Gmar, S., & Chagnes, A. (2019). Recent advances on electrodialysis for the recovery of lithium from primary and secondary resources. *Hydrometallurgy*, *189*, 105124. https://doi.org/10.1016/j.hydromet.2019.105124