Deep Eutectic Solvents (DES) assisted recovery of valuable metals from spent LMO cathode materials of Lithium-ion batteries.

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Abstract

- ✓ This research investigates the leaching efficiency using deep eutectic solvents (DES) of **ChCl: LA** as a novel and environmentally conscious means for the extraction of valuable metals of lithium manganese oxide ($LiMn_2O_4$) from spent LIBs
- ✓ Li and Mn leaching efficiencies where tested different operating parameters **DES molar ratio, temperature (°C), solid liquid ratio (S/L), time (h), presence of reducing agent.**
- ✓ Characterization of analysis were done for the raw LMO and the leached residue using **XRD, FE-SEM, EDS** and **XPS** while the leachate were analyzed using **ICP-OES.**
- ✓ The outcomes show that the leaching efficiency of both Li and Mn was found to be more than **98% leaching efficiency** with operating parameters of **DES 1:2:1** molar ratio, **20g/L of S/L ratio at 90°C** of optimum temperature with ideal reaction time of **1h**.

1. Introduction

- The global LIBs market is projected to grow at CAGR of 14.6% by 2026.
- LIBs contain valuable materials, which can be recovered and reintroduced into the market.
- This study focus on using DES (ChCl:LA) and reducing agent as an alternative greener solvent to leach the metals of Li and Mn from cathode materials ($LiMn_2O_4$) of spent LMO batteries.

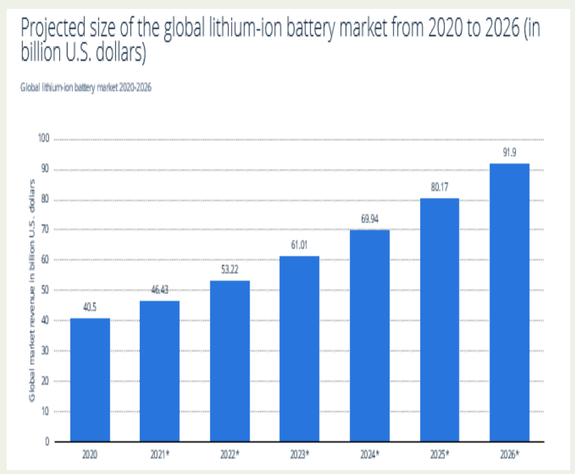


Fig.1 Global lithium-ion battery market 2020-2026. (Statista,2020)

2. Experimental Setup

2.1 Pre-treatment process

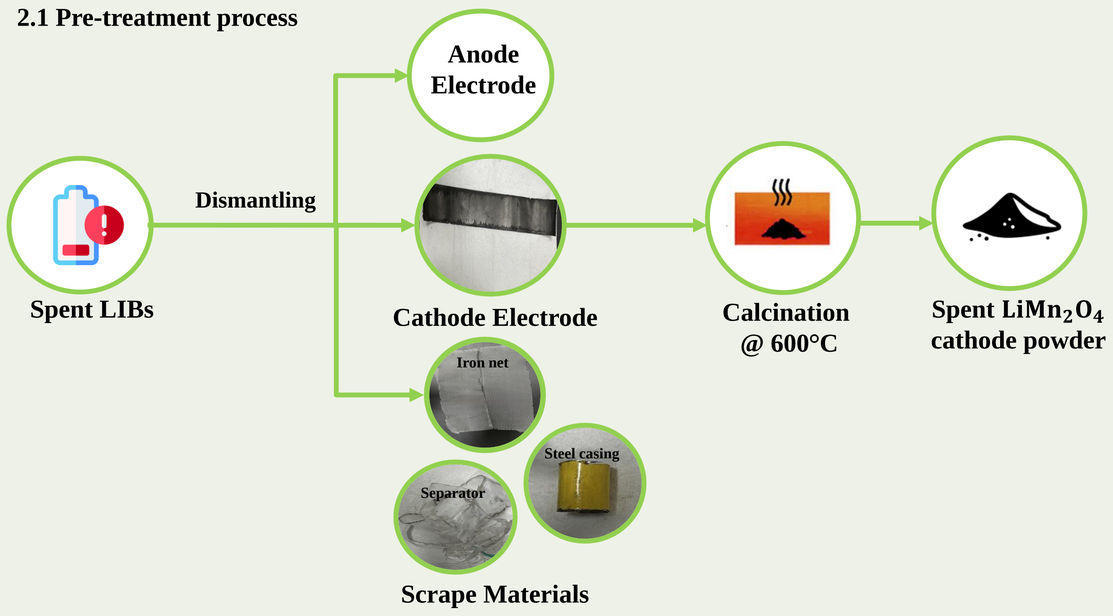


Fig.2 Flowchart of pre-treatment process for spent LMO batteries.

2.2 Preparation of DES (ChCl:LA)

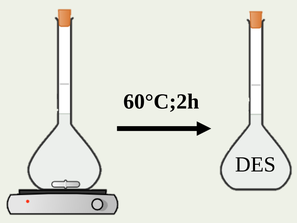


Fig.3 Preparation of DES.

- Chlorine Chloride (HOC2H4N[CH3]3CL;> 98%), Lactic acid (C4H6O6;>99.5%) and D-(+) glucose (C6H12O6;>99.5%) [Sigma-Aldrich]

2.3 Leaching Experiment

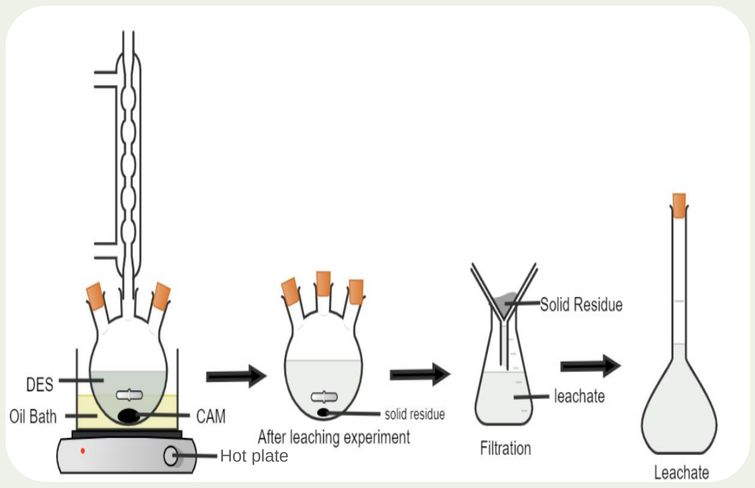


Fig.4 Schematic diagram for the process of leaching experiment.

Operating Parameters

DES molar ratio

S/L (g/L)

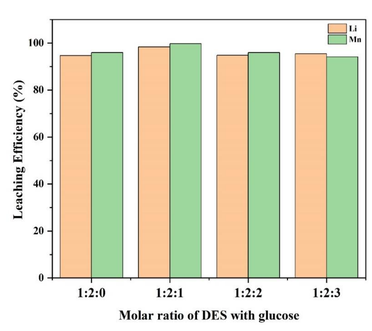
Temperature (°C)

Time (h)

Glucose molar ratio

3. Results and Discussion

3.1 ICP-OES



98% Li; 98%Mn
@ optimum conditions of
1:2:1(ChCl:LA:GLU); 20g/L; 90°C; 1h

Fig.5 Effect of operating condition on leaching efficiencies.

3.2 XRD

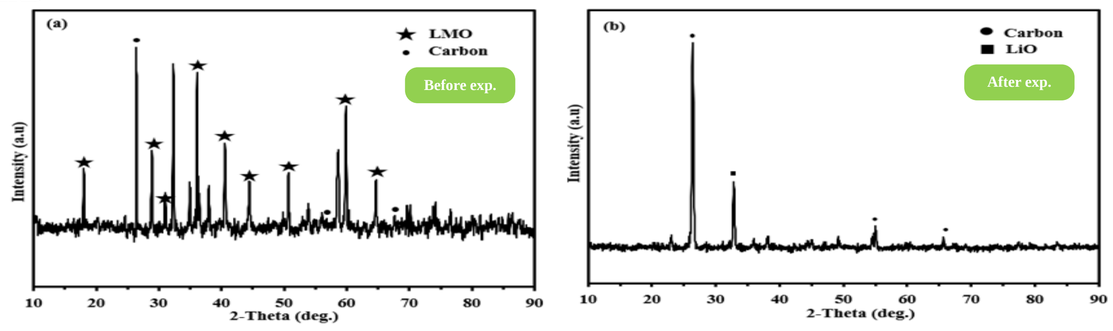


Fig.6 Effect of operating condition on leaching efficiencies.

3.3 SEM-EDS

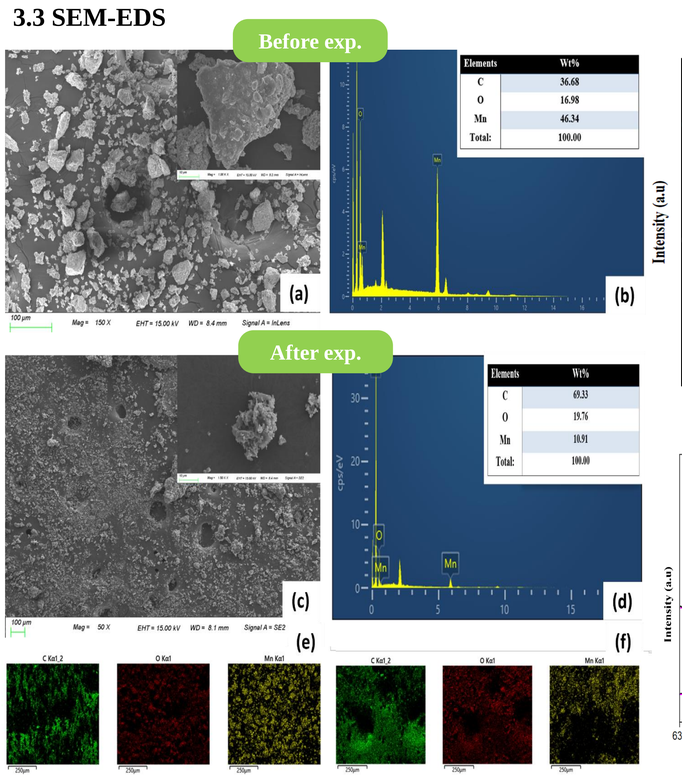


Fig.7 SEM-EDS analysis of before and after leaching experiment.

3.4 XPS

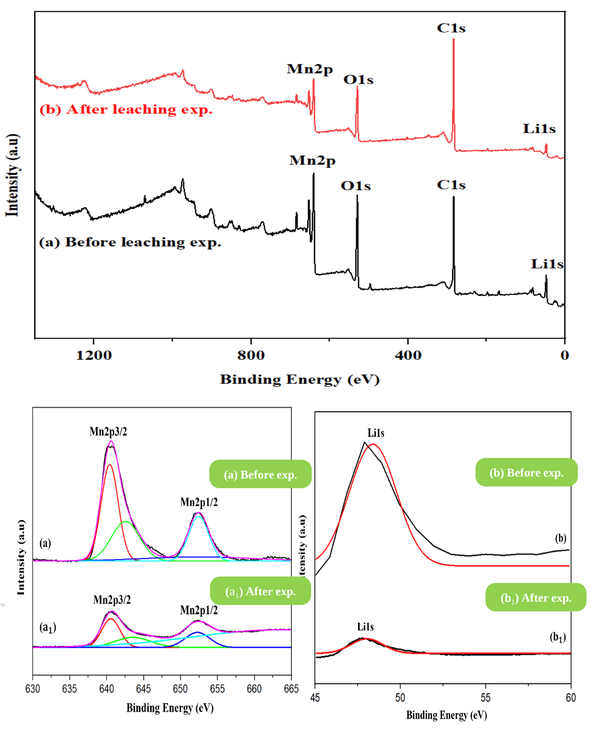


Fig.8 XPS survey and core spectra analysis of Li and Mn.

4. Conclusion

- The DES composed of choline chloride (ChCl), lactic acid (LA) and glucose achieved an impressive **98%** extraction rate for **both Li and Mn** under mild conditions **of DES:GLU molar ratio of 1:2:1, 90°C, 20g/L solid-to-liquid ratio, and 1 h leaching time.**
- Analyzing the leached residues provided insights into how the DES effectively recovered the spent cathode materials, highlighting its promise for eco-friendly recycling of battery components.
- This research demonstrates the potential of utilizing DESs to establish a circular economy for battery materials, aiding the progress towards more sustainable recycling methods.

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