ChCl:EG based solvometallurgical extraction of cathode active powder from spent lithium-ion batteries

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The recovery of lithium-ion batteries is essential to reduce potential environmental problems due to their toxic components which are critical primary sources. To reduce greenhouse gas emissions and transition to low-carbon extraction of critical metals, usage of solvometallurgical methods have increased in recent years.

The solvometallurgical leaching is a "green chemistry" application which uses the solvents based on renewable resources, biodegradable and reducing the environmental impact of the recovery process. Solvometallurgy becomes a prominent method owing to the minimum use of water, lower temperatures, almost no processing wastes and using of non-toxic solvents compared to the classical leaching methods. Additionally, solvometallurgical methods can be used to recover a wider range of metals from a variety of sources [1,2].

In this study, spent lithium-ion battery cathode active powder from same brand and same model (Bower-Original) was used as a raw material which includes Li, Ni, Mn, Co metals. Spent lithium-ion batteries were discharged in acetic acid solution for 24 hours to prevent short circut problems during dismantled of batteries. Cathode active powder were striped from cathode plate manually from aluminium foil to increase leach efficiency due to reduced amount of redundant components. XRD, TG/DTA, SEM and ICP-MS analyses were performed to characterize the cathode active powder. Based on XRD analyses, the peak observed for $LiCo_{1/3}Ni_{1/3}Mn_{1/3}O_2$ is characteristic of NMC cathode material and can be fitted within the 96-400-2444 ICDD number. In addition to the $LiCo_{1/3}Ni_{1/3}Mn_{1/3}O_2$ peak, a $LiMn_2O_3$ peak can also be observed in the 96-210-7267 ICDD number.

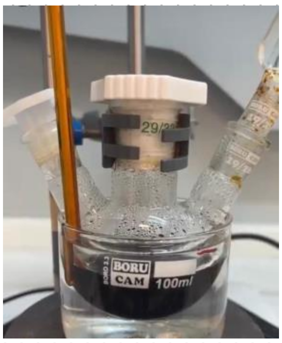

Figure 1. Oil-heated borosilicate reactor.

ChCl:EG (Choline Chloride:Ethylene Glycol) was selected as leaching solvent. Leaching processes were carried out in oil-heated, borosilicate glass reactor with 100 mL capacity (Figure 2). Leaching temperature selected between 80°C-160°C for ChCl:EG experiments. The solid/liquid ratio and stirring speed used in the process were both kept constant at 1:100 and 375 rpm, respectively. Leaching time (4-12 h) and temperature effects to leaching efficiencies were investigated. The leaching efficiency of the metals were determined by ICP-MS analysis of the leach solution.

The results of the analysis indicate that increasing the process temperature and reaction time had a positive impact on the leaching behavior of the cathode materials. This can be attributed to the fact that higher temperatures and longer reaction times promote greater solubility and reactivity of the cathode materials in the solvent system. The increase in temperature can enhance the rate of the reaction and facilitate the dissolution of metals from the cathode material into the solvent while longer reaction times provide sufficient contact time for the solvent to dissolve more of the target metals from the cathode material. Consequently, it can be inferred that optimizing the process temperature and reaction time can lead to improved leaching efficiency of the cathode materials, which can be advantageous for the recovery of critical metals from spent lithium-ion batteries.

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References

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