LEACHING OPTIMIZATION NMC CATHODE MATERIAL USING ORGANIC ACID AND REDUCING AGENT TO RECOVER VALUABLE METALS FROM SPENT LI-ION BATTERIES.

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Abstract

The structural ,morphology of the cathode materials before and after leaching were characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The amount of cobalt, and lithium present in leachate was discovered by atomic absorption spectrometry (AAS).The conditions for achieving a recovery of more than 90 wt. % of these metals were determined experimentally by varying the concentration of the leachant, leaching time and solid-liquid ratio. It was discovered that hydrogen peroxide in citric acid solution is an effective reducing agent because it enhances the leaching efficiency. Leaching with 1.5 M citric acid, 6 vol. % hydrogen peroxide

Introduction

LIBs are rechargeable batteries that store energy through reversible intercalation of lithium ions. It doesn't not involve full redox reactions, thus avoiding many of the lifetime and power-limiting problems of fully chemically battery mechanisms. The global demand for LIB raw materials and tactics in the resynthesizing process and wide range of growing applications of spent LIB materials give more attention to recycling

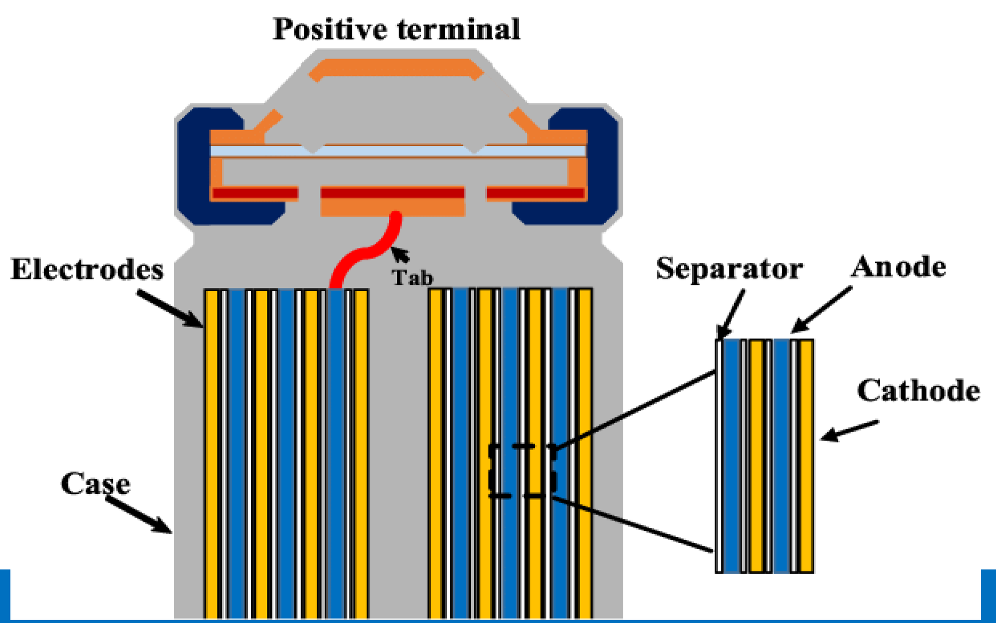


Figure 1: Structure of Li-ion battery

Aims of the research

The aim of the research on leaching NMC (Nickel, Manganese, and Cobalt) cathode materials using citric acid is to develop a sustainable and efficient method for recovery valuable metals from spent lithium-ions batteries (LIBs).This research also seek to:
Optimize Metal Recovery: Determine the most effective leaching conditions and parameters such as temperature, citric acid concentration, reaction time and solid –liquid ratio

Experimental Setup

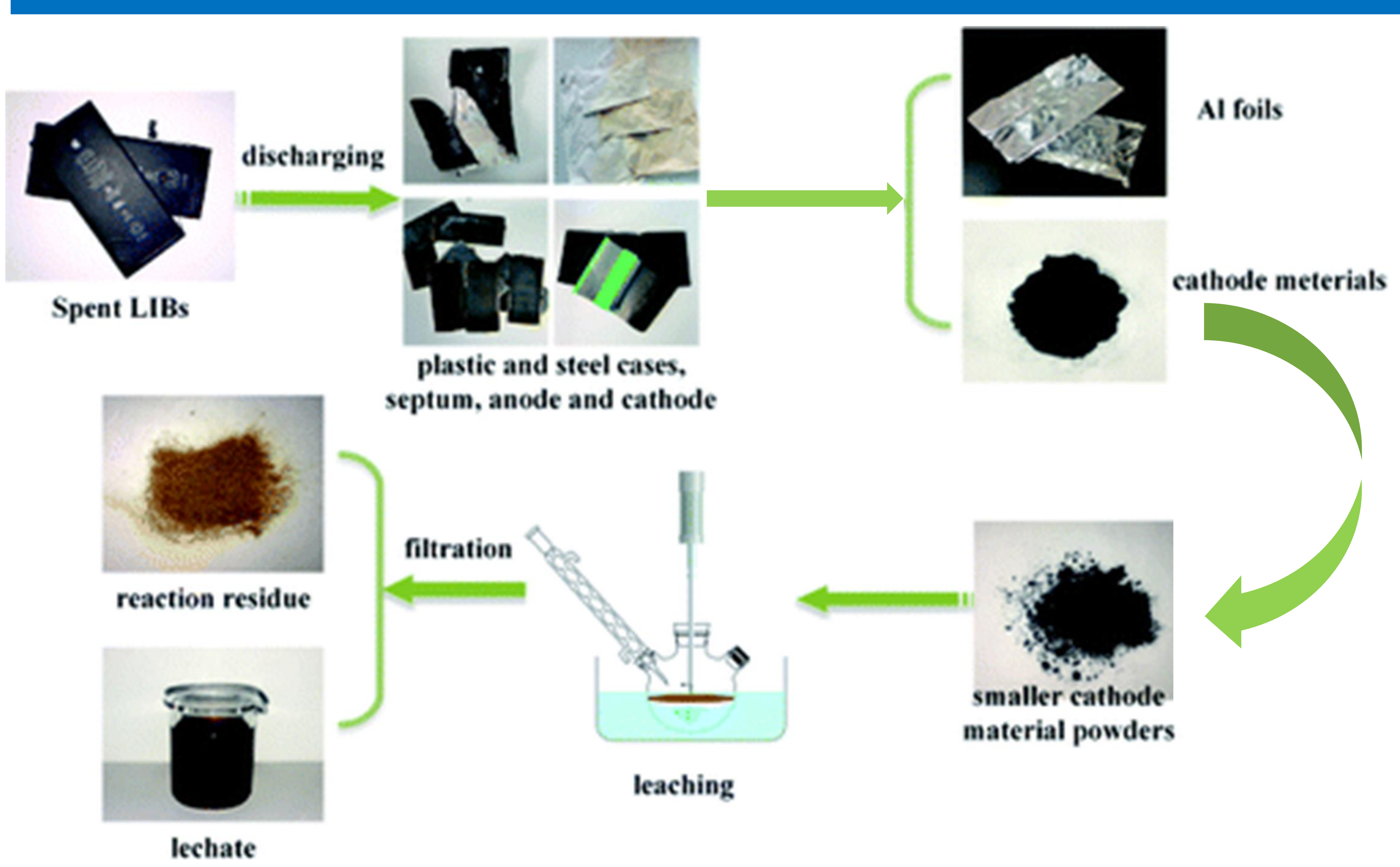


Figure 2: A process of leaching recovery for valuable metals from spent LIBs

Results and discussion

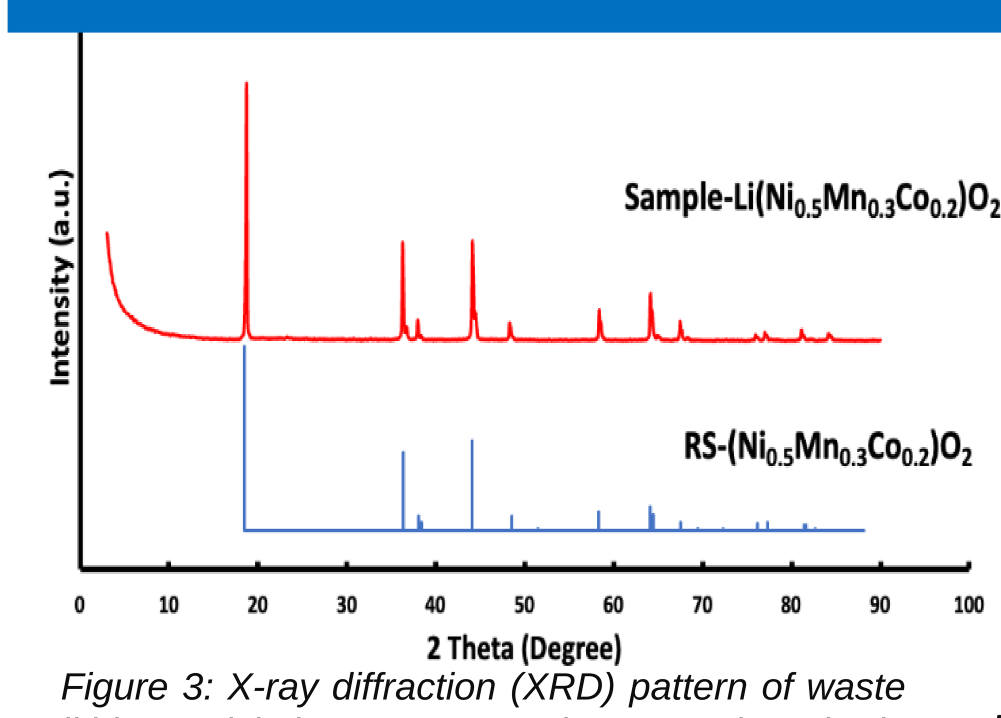


Figure 3: X-ray diffraction (XRD) pattern of waste lithium, nickel, manganese (NMC 523) cathode material .

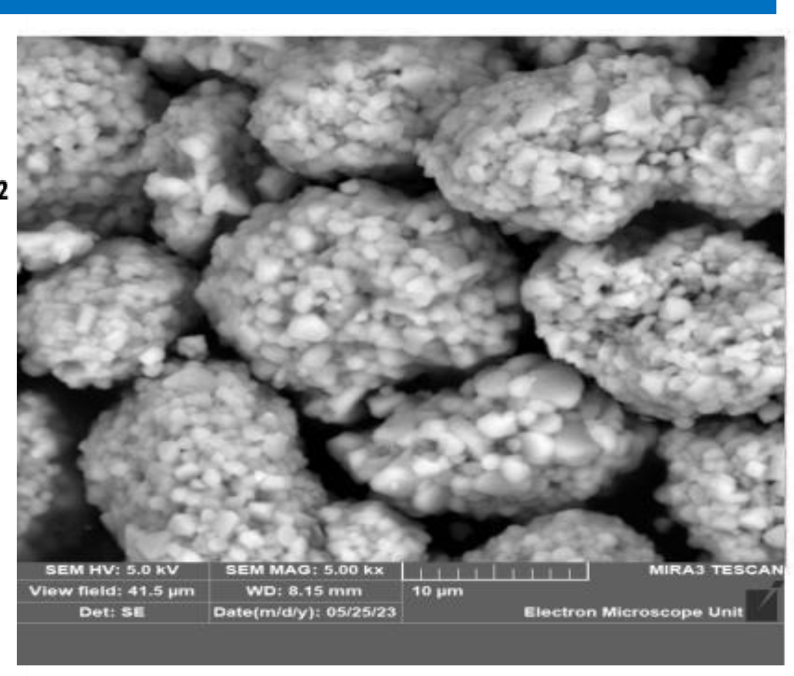


Figure 4: Scanning electron microscopy image of cathode material.

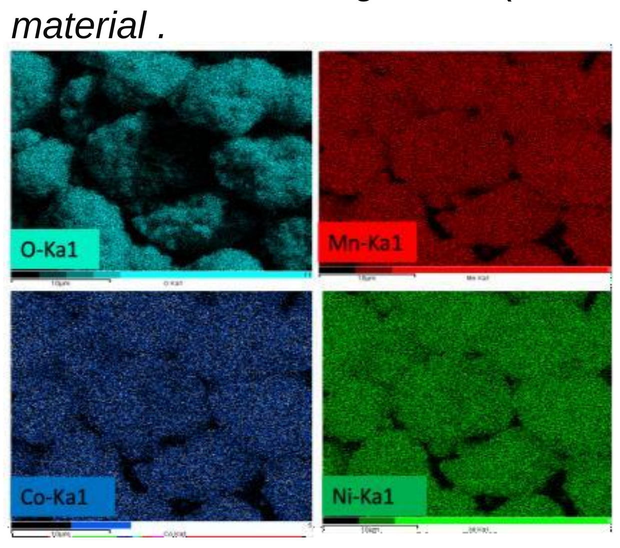


Figure 5: The energy dispersive X-ray spectroscopy EDS analysis of NMC .

As depicted in Figure 3 , the analysis indicated that the metals (Ni, Co, O and Mn) were present in the NMC 532 sample. In conclusion, the analysis successfully detected the presence of valuable metals such as Ni, Co, and Mn. The chemical and material composition of the Li-ion cathode materials was analyzed by ICP-OES, XRD, and EDS, mainly containing 18.24% Co, 44.78% Ni, 26.28 % Mn, and 10.68% Li.

Results and discussion continued….

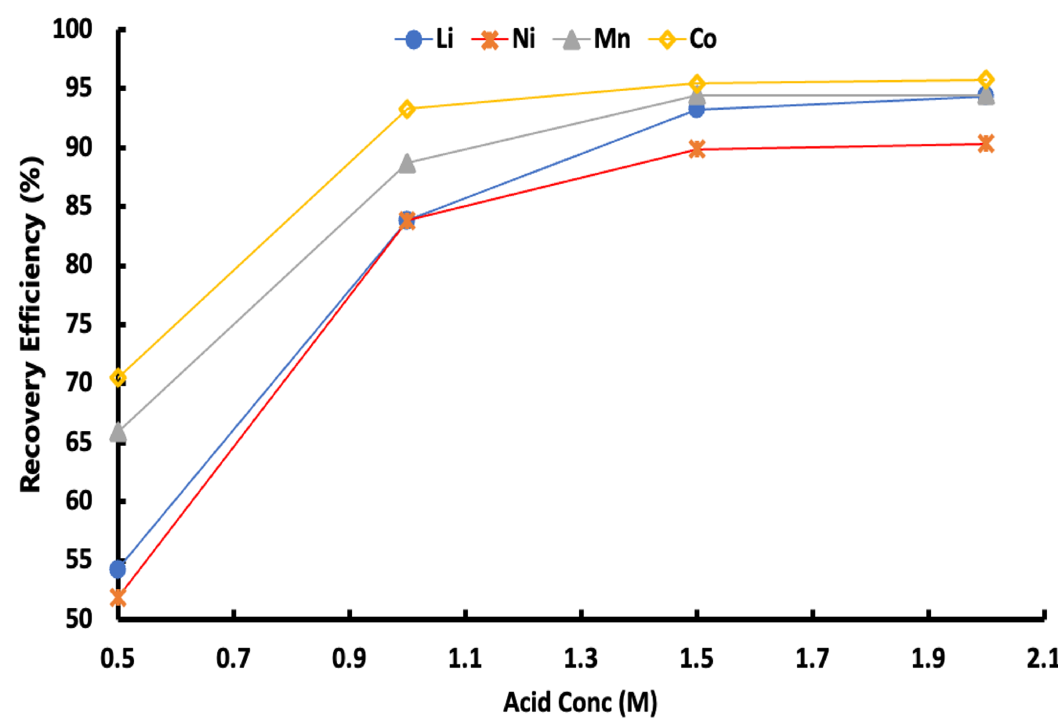


Figure 6: Effect of citric acid on the leaching of metals from cathode material

In Figure 6 as the nitric acid concentration increased to 1.5 M, the reaction efficiencies increased to 95%, 90, 90%, and 85%. From these results, we can conclude that 1.5 M OF nitric acid was optimal initial concentration.

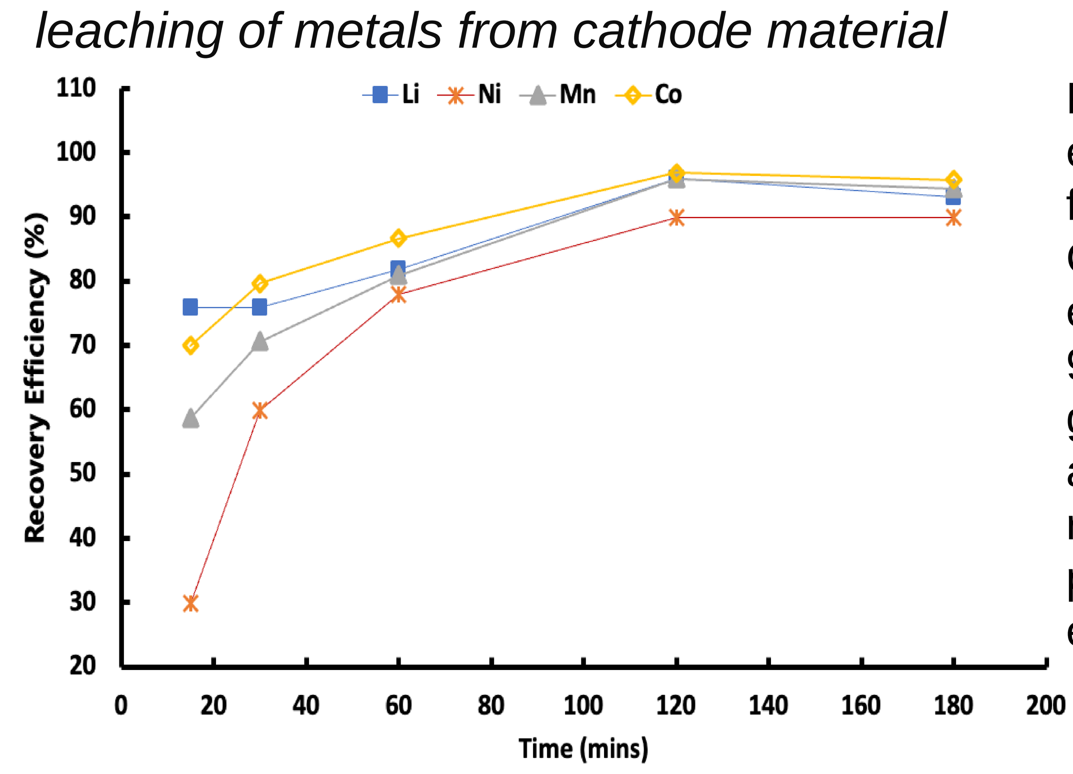
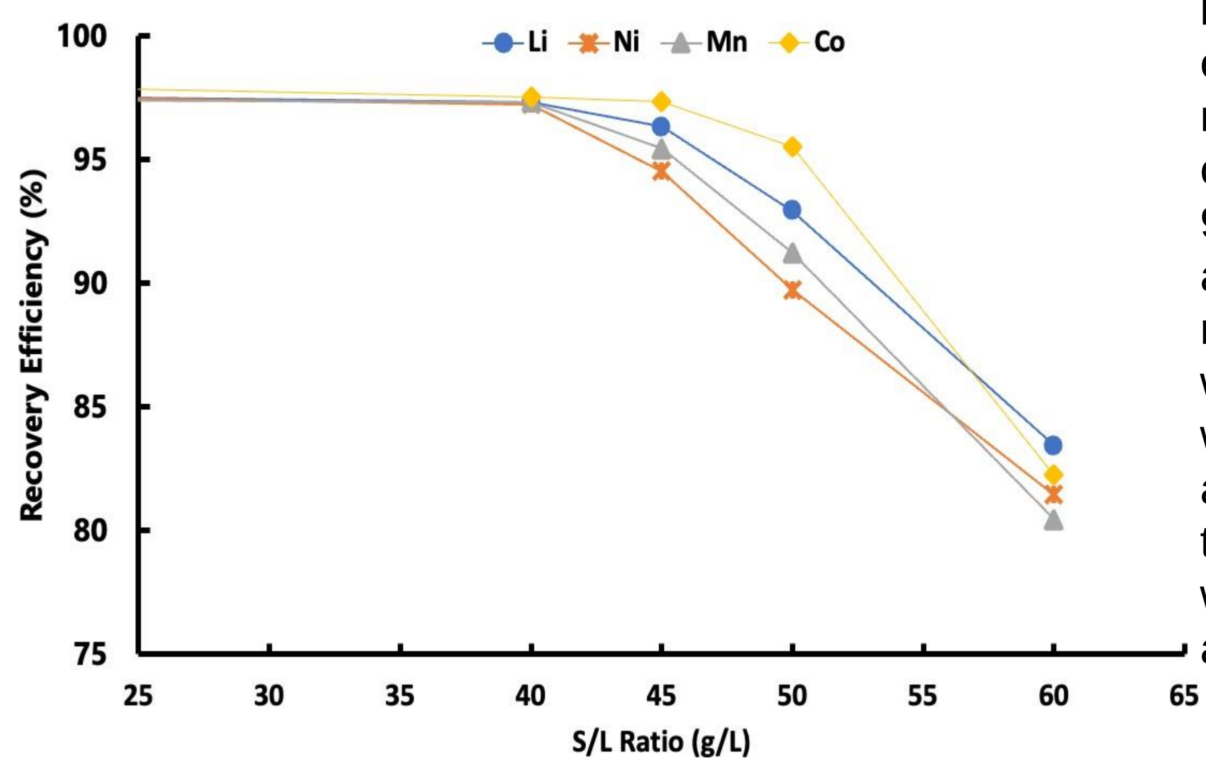


Figure 7 :effect of time leaching on C

Figure 7, for the first 30 min, the efficiency was 75% for Li, 80% for Co, 70% for Mn and 60% for Co. After that, an increase of efficiency to 85% Li, 90% Co 90% and Mn 80% when the time gets to 180 min. At 180 min almost 90% of the metals are recovered, which represents proper leaching time for the next experimental approach or study.



In Figure 8 when the solid-liquid 20 g/L, the efficiencies for lithium, manganese, nickel and cobalt were 95.5%, 95%, 94% and 96% respectively above 90%. The leaching rate reached the maximum when the solid-liquid ratio was 45 g/L because the amount of H^+ was enough to react almost completely with the metal compound at low solid-liquid ratio

Figure 8: Effect of solid-liquid ratio on the leaching of metals from cathode material

Conclusion

The leaching results demonstrated that citric acid might efficiently leach lithium, nickel, manganese, cobalt, and aluminium from used LIB cathode material. It was confirmed that when a reductive leach is performed with 1.5M citric acid, 6 vol. % H_2O_2 and 45 g/L for 30 minutes: 75% Li, 80% Co, 70% Mn, and 60% Ni were consistently leached from the cathode powder.

References

1. Alonso, E., Sherman, A.M., Wallington, T.J., Everson, M.P., Field, F.R., Roth, R., Kirchain, R.E., (2012). *Evaluating Rare Earth Element Availability*, A Case with Rev. Demand from Clean Tech. Env. Sci. Tech. 46, 3406–3414.
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