Green Solvent Systems for Sustainable Cobalt Recovery from Spent Li-ion Batteries

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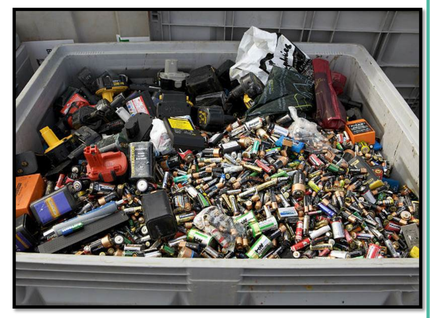
Why It Is Important to Recycle Cobalt from Spent Li-ion Batteries?

- Cobalt has a significant economic importance compared to other metals present in Li-ion batteries. (expensive, rare and usually mined in politically unpredictable areas).[1]
- Li-ion battery cathodes consist of high amounts of cobalt (~ 27 wt. %) thus by recycling could limit the risk of shortage for raw materials.[2]
- In addition, cobalt is categorized as a CMR (carcinogenic, mutagenic, and toxic to reproduction) substance, therefore cobalt in battery waste can cause environmental and health issues.[2]



Battery waste

Current Approach for Recycling cobalt from Spent Li-ion Batteries

- ❑ **Pyrometallurgy :** Involves high temperature treatments for the recovery.
- ❑ **Hydrometallurgy :** Involves the use of acidic or basic aqueous solutions for the dissolution, separation, and recovery.

Leaching (black mass/ model compounds) → **Co (II) in the leachate** → Solvent extraction / Chemical Precipitation / **Electrodeposition**

- No secondary waste
- Environmentally friendly

Leaching Reagents : acids ✖

: deep eutectic solvents (lab scale)

Deep eutectic solvents (DESs) : composed of a hydrogen bond donor and a hydrogen bond acceptor, which forms a liquid with a lower melting point than the individual components[3] **: non toxic, cost effective and biodegradable**

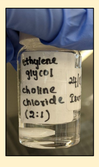
Materials and Experimental Methods

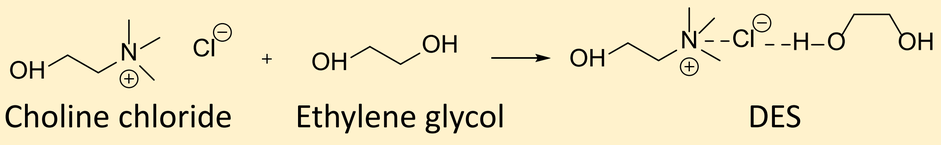
- Preparation of the DESs (ethylene glycol: choline chloride (2:1) and citric acid monohydrate : choline chloride: water (5.5:4:0.5).

- **Chemical characterization of the prepared DESs**
  - ✓ FTIR and ^{1}H NMR analysis
- **$CoCl_2.6H_2O$ maximum solubility in the DESs**
  - ✓ UV-Vis analysis
- **Co^{2+} speciation in the DESs**
  - ✓ FTIR and UV-Vis analysis
- **Co^{2+} electrochemical behaviour in DES (ethylene glycol: choline chloride) 2:1 at RT and 50 °C**
  - ✓ Cyclic Voltammetry
  - ✓ Constant potential deposition

Results

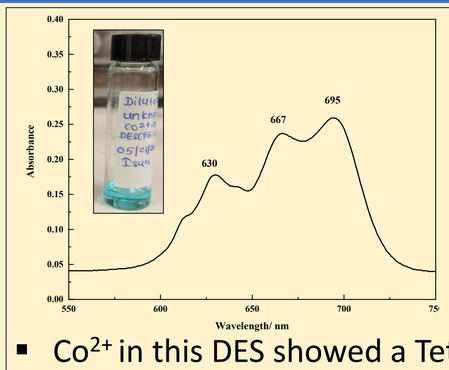
Ethylene glycol : choline chloride (2:1)



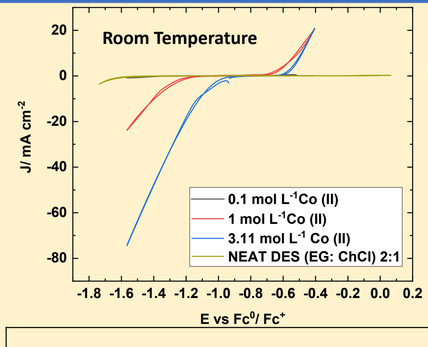


Choline chloride Ethylene glycol DES

- The obtained FTIR spectrum of this specific DES showed the same profile as the spectrum reported in the literature.[4]



- Maximum Co^{2+} solubility in this specific DES = 3.11 mol L-1
- Co^{2+} in this DES showed a Tetrahedral geometry : Blue coloured $CoCl_4^{2-}$ which is represented by the 3 signature bands between 600 nm to 700 nm



- Co^{2+} reduced at a more positive potential in higher concentration

	0.1 M	1 M	3.11 M
Current density in the reduction process (mA/ cm^2)	- 0.9	- 23	- 74
Onset potential in the reduction (V)	-1.45	-1.25	- 1.05

Conclusions

- Co(II) showed tetrahedral coordination geometry ($CoCl_4^{2-}$) in DESs at its maximum solubility irrespective of the composition of the solvent system.
- Higher concentrations (3.11 mol L^{-1}) of Co(II) in the DES composed of ethylene glycol: choline chloride (2:1) at 50 Celsius is more favourable for the Cobalt deposition . Higher current density than currently reported.[5]

Significance

This study investigates more environmentally approach by using green solvent systems for an efficient recovery of cobalt

References

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