

Study of the Hydrodynamic of Electrochemical Ion Pumping for Lithium Recovery

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Abstract : In the last decade, lithium has become an important raw material in various sectors, in particular for rechargeable batteries. Its production is expected to grow more and more in the future, especially for mobile energy storage and electromobility. Until now it is mostly produced by the evaporation of water from salt lakes, which led to a huge water consumption, a large amount of waste produced and a strong environmental impact. A new, clean and faster electrochemical technique to recover lithium has been recently proposed: electrochemical ion pumping. It consists in capturing lithium ions from a feed solution by intercalation in a lithium-selective material, followed by releasing them into a recovery solution; both steps are driven by the passage of a current. In this work, a new configuration of the electrochemical cell is presented, used to study and optimize the process of the intercalation of lithium ions through the hydrodynamic condition. Lithium Manganese Oxide (LiMn_2O_4) was used as a cathode to intercalate lithium ions selectively during the reduction, while Nickel Hexacyano Ferrate (NiHCF), used as an anode, releases positive ion. The effect of hydrodynamics on the process has been studied by conducting the experiments at various fluxes of the electrolyte through the electrodes, in terms of charge circulated through the cell, captured lithium per unit mass of material and overvoltage. The result shows that flowing the electrolyte inside the cell improves the lithium capture, in particular at low lithium concentration. Indeed, in Atacama feed solution, at 40 mM of lithium, the amount of lithium captured does not increase considerably with the flux of the electrolyte. Instead, when the concentration of the lithium ions is 5 mM, the amount of captured lithium in a single capture cycle increases by increasing the flux, thus leading to the conclusion that the slowest step in the process is the transport of the lithium ion in the liquid phase. Furthermore, an influence of the concentration of other cations in solution on the process performance was observed. In particular, the capturing of the lithium using a different concentration of NaCl together with 5 mM of LiCl was performed, and the results show that the presence of NaCl limits the amount of the captured lithium. Further studies can be performed in order to understand why the full capacity of the material is not reached at the highest flow rate. This is probably due to the porous structure of the material since the liquid phase is likely not affected by the convection flow inside the pores. This work proves that electrochemical ion pumping, with a suitable hydrodynamic design, enables the recovery of lithium from feed solutions at the lower concentration than the sources that are currently exploited, down to 1 mM.

Keywords : desalination battery, electrochemical ion pumping, hydrodynamic, lithium

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