

Selective Separation of Usable Metal Ions from Sea Water Using Electrochemical Method

Guoqing Guan, Abuliti Abudula

North Japan Research Institute for Sustainable Energy, Hirosaki University

Summary

There are a large amount of high value-added metal ions existed in the sea water with very low concentration. It is expected to develop novel technology for the adsorption and recovery of them economically and efficiently. It is estimated that there are about 230 billion tons of lithium resources in seawater. To date, the most effective way to recover these lithium resources is using lithium adsorbents. However, the efficiency of lithium adsorption needs to be improved, and secondary pollutants occur during desorption process because a large amount of acid will be used during this process. To solve these problems, electrically switched ion exchange (ESIX) process, which combines ion-exchange and electrochemical processes so that the ion can be selectively adsorbed/desorbed in/from the electroactive materials by controlling redox potentials, is considered in the present study. Theoretically, using this method, the adsorption amount for the target metal ion will be much more than the sole ion-exchange process. Especially, the adsorbed ions can be completely recovered by tuning redox potentials combined with the ion-exchange process. No any secondary pollutants will be produced. However, the key to realize this process is to develop efficient electroactive materials with large ion-exchange capacity and high operation stability. In this study, a method named one-step unipolar pulse electro-polymeriation (UPEP) method was successfully applied to combine spinel LiMn_2O_4 nanorods, which has high selectivity to lithium ions, and conductive polymer of polypyrrole (PPy) on the electrode to obtained an electroactive PPy/ LiMn_2O_4 composite ion-exchange membrane for the separation of lithium ions from seawater. The physical and chemical properties of the obtained membrane were characterized using SEM-EDS, XRD, TGA and FT-IR. Cyclic Voltammetry (CV) measurements combined with Electrochemical Quartz Crystal Microbalance (EQCM) were applied to characterize quantitatively the electrochemical uptake/release process of lithium ions in the obtained electroactive membranes. It is found that the ion-exchange capacity reached 39.9 mg/g-membrane in 0.5 M lithium solutions. Long-term continuous electrochemical uptake/release test indicated that the ion-exchange ability was very stable. A simulated seawater contained 0.005 M Li^+ ions and 0.495 M Na^+ ions was used for examining its selectivity for Li ions, and found that the separation factor of Li^+/Na^+ reached 124. It is expected that the obtained electroactive PPy/ LiMn_2O_4 composite ion-exchange membrane can be applied for the recovery of lithium from real seawater.

Keywords: Electrically switched ion exchange process; lithium; seawater; electroactive membrane.