Fundamental Study of Lithium Ion Battery Recovery

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Objectives

- **Recover Li, Co, Ni and Mn metal values from cathode material of spent lithium ion batteries.**
- **Synthesize new cathode material $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ with recovered materials.**
- **Study how the impurities (Fe, Cu and Al) will affect the crystal structure and electrochemical properties of synthesized cathode materials.**
- **Develop a discharge process for spent lithium ion batteries.**
- **Separate Mn, Co, Ni metal values from each other.**

Introduction

Lithium ion battery (LIB) are being widely used in portable electronics, hybrid/electric vehicles and large scaled grid storage. However, because of capacity fading, the lifetime of LIB is only a couple of years. After this period of time, they start to perform a significant lower capacity and should be disposed. The rapidly growing product amount of LIBs worldwide motivates people to consider the importance of recycling them, from both the viewpoints of economic attraction and the environment protection.

Although Europe has started to recycle lithium ion batteries, in U.S LIBs still get landfilled, which is a potential harm to human health. The salt in electrolyte reacts with water in the nature environment and the resultant is hydrofluoric acid, a very hazardous chemical. Other than that, some valuable metal elements, such as Cu, Fe, Ni, Co and Mn, will be wasted during burying the batteries into ground.

This NSF-IUCRC supported project aimed at synthesizing new cathode material with recovered valuable elements from spent lithium ion batteries, and examining the effect of impurities such as Fe, Cu and Al to the properties of new synthesized $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ cathode materials – the final product of the recovery process. Al, Fe and Cu are the possible contaminants for the recycled cathode materials. Figure 1 shows the XRD patterns of standard NMC and synthesized NMC by recovered materials[1]. Along with that, Mn, Co and Ni metal values will be separated from each other for further applications.

Methodology

The project included three main steps, as roughly shown in Figure 2:
1. Synthesize pure $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ with commercial $CoSO_4.7H_2O$, $MnSO_4.H_2O$, $NiSO_4.6H_2O$ as benchmark.
2. Add different amount of Al and Cu impurities to the product of step 1. Compare the crystal structures and the electrochemical properties at different level of impurities.
3. Synthesize $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ with recovered materials from spent lithium ion batteries and examine the structure and electrochemical properties.

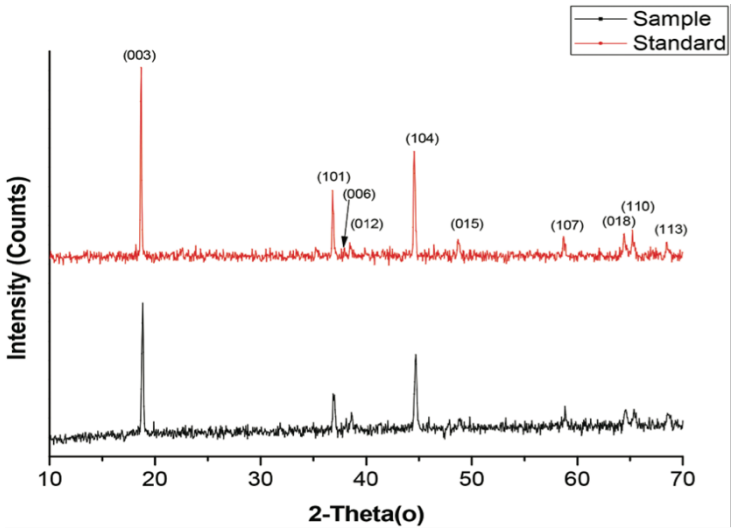

Figure 1

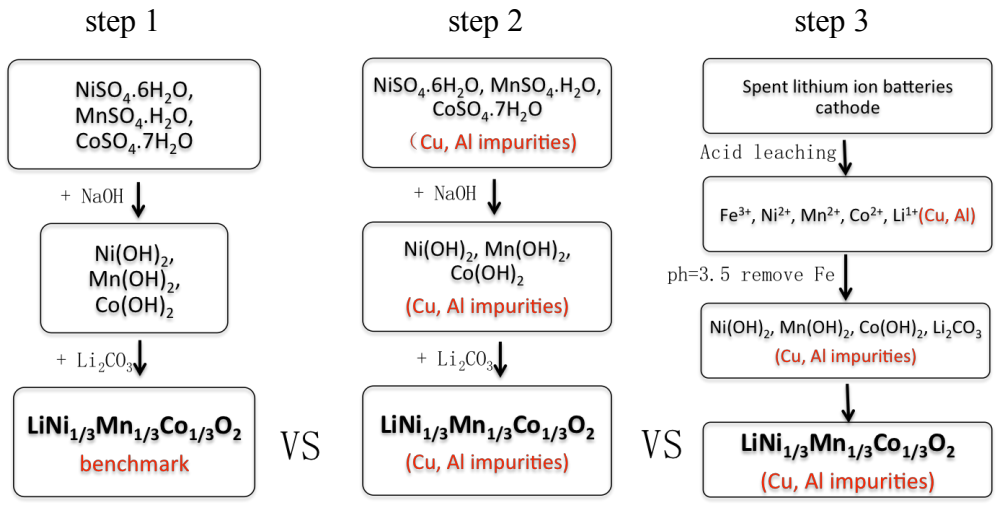

Figure 2

Reference

1. Zou, H., et a!., A novel method to recycle mixed cathode materials for lithium ion batteries. Green Chemistry, 2013. 15(5): p. 1183-1191.