Process Development in Synthesis and Recycle of Lithium Ion Battery Cathode Material

By

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Abstract

Li-ion batteries (LIBs) are widely used in portable electronic devices and electric vehicles. LiFePO4 (LFP) has been one of the most promising cathode materials for LIBs due to its high theoretical specific capacity. This thesis aims at developing a causal table which summarizes the effect of all particle quality factors on battery performance. A critical assessment was performed to validate the causal table by measuring the particle qualities of commercial LFP. The SC sample with small particle size, plate-like morphology, and carbon coating had the best specific capacity (164.9 mAh g⁻¹ at 0.1C) and rate capability (88.5% at 1.5 C). With the causal table, desired particles quality can be identified to enhance the battery performance. The particle synthesis methods and their operating conditions are then selected to ensure particles with the desired attributes can be produced. The LFP particles should be designed with a good particle quality to have a good electrochemical performance, including nano-size, rod-like morphology, and uniform carbon coating. The optimal conditions for synthesis of nano-size carbon coated LFP particle by polyol refluxing process is summarized, and the physical properties of four different morphology LFP and the electrochemical performance are measured. The sample with small particle size (140*35 nm), rod-like morphology, and around 2.9 wt.% carbon coating had the best specific capacity (160.5 mAh g⁻¹ at 0.1C) and rate capability (77.1% at 1.5 C). Recycling of spent LIBs receives increasing attention in recent years, and chemical precipitation and solvent extraction have been widely applied in the recycling process of spent LIB. Solid-liquid equilibrium (SLE) phase behavior governs the products to be recovered from the precipitation process and can be used to guide and optimize the process. Case studies on the recycling of LiFePO4 and LiCoO2 have been studied in this thesis to demonstrate how the SLE phase behavior can be used to design the recovery process. The SLE phase behavior can be utilized to determine the optimal operating conditions such as the amount of precipitant to be added to the system. With the insights provided from the SLE phase behavior, new process alternative with solvent extraction can be generated. Process alternative can be compared with the base case process to come up with the optimal process for recycling metal salts from spent LIB.

Date: 16 February 2015 (Monday)
Time: 16:30
Venue: Room 4577 (Lift 27-28)

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- ALL ARE WELCOME -