

HIGH PERFORMANCE ELECTRODE MATERIALS FOR LITHIUM RECHARGEABLE BATTERIES

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INTRODUCTION

The exponentially growing demand for portable electronics, such as laptop computers and cell phones, has rapidly increased interest for the development of more efficient Li-ion batteries. Commercial cells use either LiCoO₂ or LiMn₂O₄ (1) as 4 V cathode active materials. These materials have specific capacities around 140 and 120 mAh/g respectively. High energy density and high rate capability are two important factors where improvements are needed considering many device applications. There is a considerable improvement in energy density and rate capability of LiCoO₂ when an inert ceramic material is introduced in to this material as a distinct separate phase (2-4). To improve specific capacity further, materials isostructural with LiCoO₂, like LiNiO₂ were looked in to (5-6). LiNiO₂ with specific capacity around 200 mAh/g would be an ideal high energy density material. Stabilizing Ni³⁺ in 2D layered structure resulted in poor material qualities leading to unacceptable electrochemical behavior. The higher specific capacity of LiNiO₂ compare to LiCoO₂ is too good to be overlooked and at the same, higher irreversible capacity, poor cycle life and safety factors associated with it makes it unattractive as far any applications are concerned. To overcome the difficulties, forming a solid solution between LiCoO₂ and LiNiO₂ was proposed (7-9). Such a material would be expected to provide the required structural stability and favorable electrochemical properties. The other factor to be considered in realizing high performance of the active material is rate capability. One way to enhance the rate capability of the material is to improve the processing conditions during electrode manufacturing. Generation of pores and lamination of the electrodes, which has good control over the SEI (Solid Electrolyte Interface) layer formation, improves the rate capability, not only of the active material, but also of the battery as demonstrated in the lithium polymer battery development (10). In this communication we focus on the synthesis of LiNi_{1-x}Co_xO₂ materials to realize their full potential as far as the specific capacity and modified processing conditions to improve the rate capability.

EXPERIMENTAL

In addition to ceramic method, LiNi_{1-x}Co_xO₂ materials are synthesized by a modified sol gel process utilizing ascorbic acid and ammonium hydroxide as chelating agents and using appropriate precursor salts. Soft-chemistry approaches like sol gel have helped to produce consistently high quality oxides with optimized electrochemical properties. Liquid-type cells (using Carbon or Li as anode) were built and tested at various current densities in the voltage range 3 – 4.3 V.

RESULTS AND DISCUSSION

Investigation of LiNi_{1-x}Co_xO₂ solid solution showed that materials with high specific capacity and still preserving structural integrity are produced. Bulk LiNi_{0.8}Co_{0.2}O₂ materials (optimum Co value at 20%) gave

excellent performance. At 0.5 mA/cm² (C/3 rate), a first discharge capacity of \approx 200 mAh/g is obtained. The irreversible capacity loss was at \leq 7% for all these materials indicating the high quality nature of the oxide powders. The specific capacity obtained for the mixed oxides thus represent about 30 % increase in capacity compare to LiCoO₂ materials. At the same time, composite LiCoO₂ materials (i.e. 2 phase LiCoO₂ with inert metal oxides) exhibit 85 % capacity retention at 5 mA/cm² (3.5 C rate). Improving process conditions during electrode manufacturing helped to achieve > 75 % capacity retention at the same current density. Work is in progress to match up to the rate capability of composite LiCoO₂ materials, so that LiNi_{0.8}Co_{0.2}O₂ materials would be an ideal choice for commercial use in Li-based batteries. Detailed results will be available during the presentation.

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