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Lithium Ion Batteries Based on Polymer Modified V_2O_5 Cathode Materials

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Introduction

The high theoretical capacity of V_2O_5 (~600 mAh/g) makes it an attractive material for application in rechargeable lithium ion batteries. The practical reversible capacity (~150 mAh/g) of V_2O_5 and low voltage (2.8-3.0 V vs. Li/Li^+) make it a poor choice relative to the more energetic, state-of-the-art Co and Mn oxide cathode materials. Accessing more of the available capacity, in a reversible fashion, is the key to making V_2O_5 competitive.

Physical Sciences Inc. is developing a polymer modified V_2O_5 based cathode material that shows promise for application in specialized lithium ion batteries. Sol-gel synthesis of the V_2O_5/polymer composite provides a unique route to the fabrication of a nano-featured material with molecular level mixing. This sol-gel is easily processed by heat treatment and subsequent grinding or spray drying to yield particles that are suitable for slurry based cathode fabrication techniques. Initial experiments with this cathode material deposited as a thin film showed a reversible capacity of 350 mAh/g.

Experimental

The cathode material was synthesized by a sol-gel technique utilizing the hydrolysis reaction of vanadium (V) oxytriisopropoxide in the presence of the polymer additive. These materials were spray dried or dried to the xerogel and ground to yield particles. Cathode slurry was made by combining cathode material, conducting carbon and binder in various ratios. The slurry was deposited by doctor blade on aluminum foil current collectors for testing. Data for half (Li anode) and full cell (graphite anode) charge/discharge experiments were obtained with a Maccor battery tester. Molar $LiPF_6$ in 1:1 ethylene carbonate:dimethyl carbonate electrolyte and Celgard 2730 separator material was used in all the cells tested.

Results and Discussion

Figure 1 shows the cross section of a slurry deposited cathode containing 90% V_2O_5 composite cathode material, 5% carbon and 5% binder (w/w). As deposited, the calculated cathode solids packing was approximately 60% and the slurry was well adhered to the current collector.

Figure 2 shows the behavior of a V_2O_5 composite cathode discharged opposite a lithium anode over the first 10 cycles. After the initial fade, capacity remains reasonably constant at approximately 220 mAh/g. Continuing improvements in material processing and cell design are anticipated to allow us to approach the 350 mAh/g potential of this material.

In this presentation we will further discuss the performance of the composite cathode material and present data from full cell experiments. Additionally we will consider the physical characterization of the composite cathode material and offer a future course of action for this promising system.

Figure 1. The cross section of a slurry derived V_2O_5 cathode. The image was obtained with a FESEM at 1000X magnification.

Figure 2. Voltage vs. capacity discharge plots for a slurry derived V_2O_5/polymer composite cathode. Discharge rate was C/2.