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Effect of Morphology on the Li$^+$ Diffusion Coefficient for Nickel Oxide Anodes in Li-ion Batteries

Neil Spinner and William E. Mustain

Department of Chemical and Biomolecular Engineering
University of Connecticut
Storrs, CT 06268

Lithium-ion batteries have become the most popular source of power for portable electronics, owing primarily to the development of high capacity, high stability electrode materials [1]. On the anode side, graphitic carbon has been extensively used due to its low cost and stability [2], though in recent years the focus has shifted to finding higher capacity materials. Nickel oxide (NiO) has been shown to be a promising candidate for the Li-ion battery anode due to higher theoretical capacity (718 mAh/g for NiO vs. 372 mAh/g for carbon), ease of synthesis, and low cost [3,4]. However, the effect of NiO morphology resulting from different synthesis methods on battery performance is often unknown.

To examine the effect of morphology on anode performance, Cyclic Voltammetry (Figure 1) and charge/discharge cycling tests were conducted. Additionally, Li$^+$ diffusion coefficients were calculated experimentally using the current pulse relaxation (CPR) method, Equation 1 [5]:

$$E - E_i = \Delta E = \frac{\left({}^{dE}\!/_{dx}\right) V i \tau}{AF\sqrt{\pi D t}} \qquad (1)$$

During CPR tests, a short (5 second) pulse of current was applied in order to draw Li$^+$ ions into the anode microstructure, resulting in a small potential change. The subsequent relaxation of potential (ΔE) back to the original value was monitored as a function of time (t), and the diffusion coefficient, D, was extracted from the slope of ΔE vs. $1/t^{1/2}$ using Eq. 1.

For this work, NiO was synthesized using two different aqueous-phase precipitation techniques [6] and coin cells were fabricated using Li metal as the cathode, Celgard 2320 as the separator, and 1M LiPF$_6$ in 1:1:1 EC:DEC:DMC as the electrolyte. G5 graphite (CPreme) was used as a reference anode material. CPR tests were performed and Li$^+$ diffusion coefficients were calculated from the data. The effect of NiO morphology on the values for D will be discussed, and a preferred NiO synthesis technique will be identified. Comparisons in cycling stabilities and capacities of NiO and carbon anodes will also be examined.

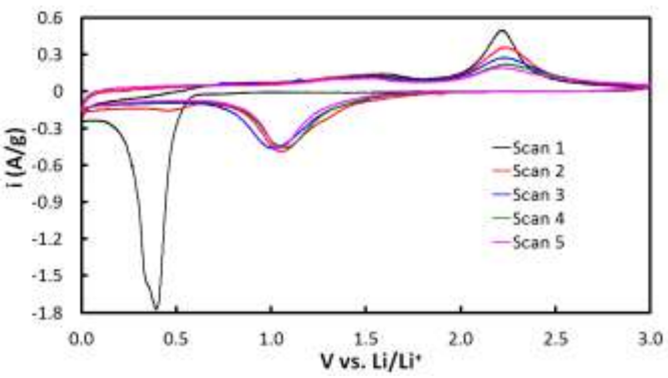

Figure 1 – Cyclic voltammograms for first 5 scans of NiO anode. Tests performed at 0.1mV/s in coin cells with Li metal cathode and 1M LiPF$_6$ in 1:1:1 EC:DEC:DMC electrolyte.

References:

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