Preparation and electrochemical performance of doped $LiNi_{1-x}Co_xO_2$ cathode materials

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Lithium nickel cobalt oxide is one of the most attractive positive-electrode materials for lithium–ion batteries. This material can deliver high capacity (up to about 180 mAh/g) with accessibly high operating voltages when the charge and discharge cutoff voltage is regulated between 4.3 and 2.75V against a lithium electrode [1]. Nevertheless, the traditional solid state reaction requires prolonged heat treatment time at high temperatures. Furthermore, these high temperature treatments generally cause the inhomogeneous of Ni/Co distribution in $Ni_{1-x}Co_xO_2$ slabs due to the formation of cobalt clusters [2]. In last years, some soft-chemical methods have been used for the preparation of lithium nickel oxide and its derivatives, such as co-precipitation and sol-gel methods [3,4]. In this reports, some doped $LiNi_{1-x}M_xO_2$ such as $LiNi_{1-x}Co_xO_2$ materials where x=0,0.1,0.2,0.3 by a sol-gel method and their electrochemical behavior will be presented.

XRD patterns of $LiNi_{1-x}Co_xO_2$ compounds (x=0,0.1,0.2,0.3) are shown in Fig.1. In the entire composition range, a single $LiNiO_2$ phase is obtained and all diffraction lines can be indexed assuming a hexagonal lattice of α -$NaFeO_2$ type. There is no indication of any impurity phase.

The peak intensity radios of (003) to (104) of the XRD spectra are plotted against various compositions x in Fig.2. The radio is increased as the value x increased. The radios of lattices of c/a are also plotted against x in Fig.2. The radio c/a also increased as the value of x, which is good in accordance with the result of ratio of I (003) / I (104). The expansion of the c axis as x value increases might improve the stability of layered structure when Li^+ intercalated into host oxides.

Fig.3 is a plot of the discharge capacity vs. cycle number of $LiNi_{1-x}Co_xO_2$ for x= 0,0.1,0.2,0.3. Composite electrodes were prepared by 85 wt % $LiNi_{1-x}Co_xO_2$, 10 wt % acetylene black and 5 wt % PTFE. The counter electrode was Li sheet. The electrolyte was $LiPF_6$/EC+DMC(1:1). The button cells were cycled under a constant current at a rate of 0.1C with charge and discharge cutoff voltages of 4.3 and 3.0V(vs. Li^+/Li). In compared to the other materials, $LiNi_{0.8}Co_{0.2}O_2$ delivers the highest initial capacity of 182mAh/g while $LiNi_{0.9}Co_{0.1}O_2$ exhibits the best cycling stability. The latter shows a first discharge capacity of 172mAh/g while fades to 164mAh/g in 8 cycles thus indicating a fade of 0.58%/cycle.

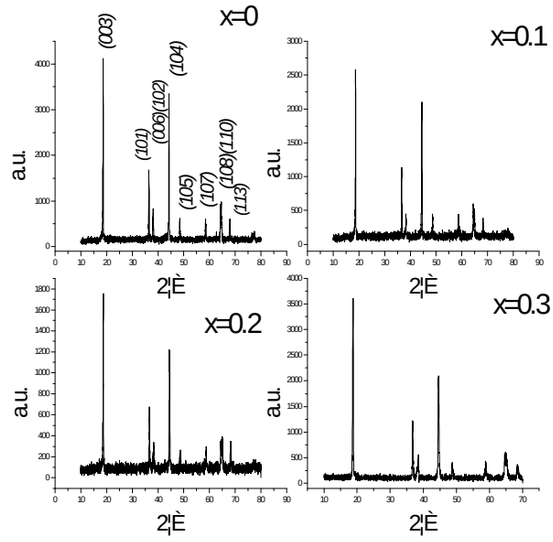

Figure 1 XRD patterns of $LiNi_{1-x}Co_xO_2$ with x=0,0.1,0.2,0.3

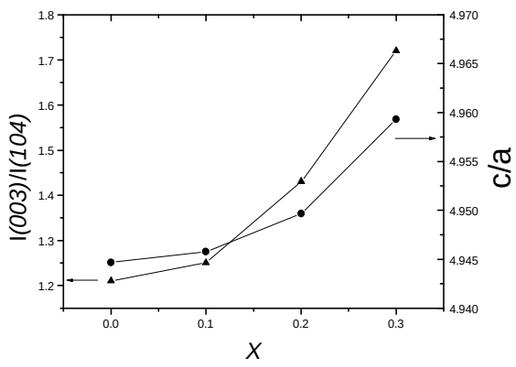

Figure 2 The *I(003)/I(104)* radio and *c/a* radio against x of $LiNi_{1-x}Co_xO_2$

The different *dt/dV* vs. voltage plots for $LiNi_{1-x}Co_xO_2$ are shown in Fig. 4. The results indicate the phase transitions occur during charge and discharge cycling. The sharp peaks are gradually diminished by cobalt substitution and are not observed for $LiNi_{0.7}Co_{0.3}O_2$ which

indicates that a single-phase reaction may occur for the lithium nickelate with 30wt% cobalt substitution.

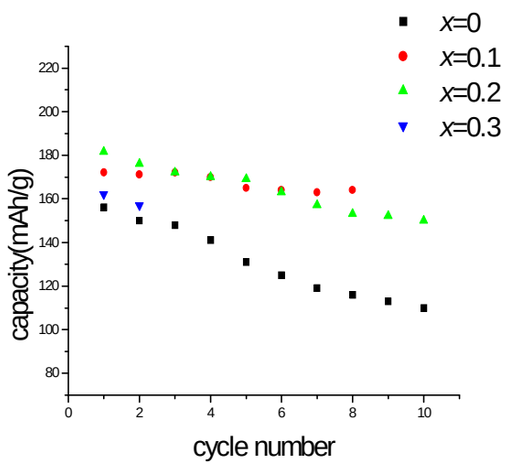

Figure 3 The capacity vs. cycle number plot for $LiNi_{1-x}Co_xO_2$ with x=0,0.1,0.2,0.3

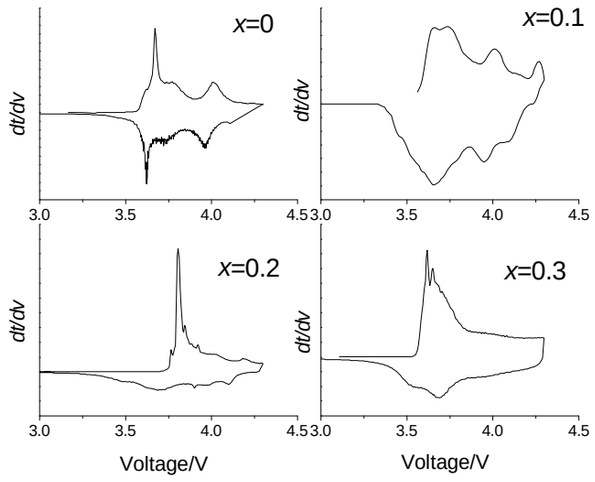

Figure 4. The *dt/dV* vs. Voltage (vs. Li^+/Li) line for $LiNi_{1-x}Co_xO_2$ with x=0,0.1,0.2,0.3

The thermal and electrochemical behavior of $LiNi_{1-x}Co_xO_2$ and other doped lithium-nickel-oxides with Mg, Ti and Sn are also investigated. The effects of doping elements on electrochemical performance and thermal stability of those doped lithium-nickel-oxides will be discussed based on systematic results.

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