Development of Novel $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ / C System Li-ion Cells

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Introduction

The NiOOH with a large theoretical capacity of 292 mAh g^{-1} has been considered to be a promising candidate of positive active material for 3-volt-class lithium cells.[1,2] However, this material was impossible to be used for the positive electrode for Li-ion cells with carbon negative one because of no lithium source in the discharged state. Recently, we have succeeded in the synthesis of NiOOH・Li by new chemical method with Li-naphthalene complex solution.[3]

Li-ion has been doped into $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}$ as one of precursors for the derivative positive active materials of NiOOH by the new chemical method. The $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ positive electrode using this synthesized active materials doped with lithium has been investigated for its cycleability with the practical cells under the condition of the starved electrolyte, wherein x is $0 \leqq x \leqq 1$. The novel Li-ion cell has been found to be a 3-volt-class high-energy-density cell with good cycle-ability. In this report, we will discuss the performance of these new cells with $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ positive active materials together with the electrochemical reaction mechanism of charge and discharge process.

Experimental

The $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ positive electrode was prepared by immersing the electrode composed of $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}$, acetylene black (AB), and poly-vinylidene-fuluoride (PVDF) using Al current collector into the complex solution with 0.25 mol dm^{-3} naphthalene and saturated metallic Li in 1-methoxybutane solvent for a different times followed by washing it with dimethyl carbonate (DMC). The negative electrode was composed of graphite, styrene butadiene rubber (SBR), and carboxylic methyl cellulose (CMC) using Cu current collector. The test laminate-type single cells were prepared with both electrodes, polyethylene film separator, and the mixture electrolyte of ethylene carbonate (EC) and diethyl carbonate (DEC) with the concentration of 1 mol dm^{-3} $LiClO_4$. The test cells were discharged to 1.4 V at current density of 0.25 mA cm^{-2} after charging to 4.1 V.

Results and Discussion

The initial charge-discharge characteristics of representative $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ / C system Li-ion laminate-type cell are shown in Figure 1. This cell shows monotonous discharge curve with 3-volt-class voltage, though the irreversible capacity is still observed at the present time. The cycle performance of the laminate-type test cell is shown in Figure 2. This cell shows good cycleability with the discharge capacity retention of 90% at 20 cycles. The good cycleability of this system is considered to be the reason for the starved electrolyte condition of laminate-type single cell judging from the fact that the cycleability of NiOOH positive electrode derivative of $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}$ active material was very poor in flooded condition of electrolyte.[2]

The electrochemical charge-discharge reaction mechanism of novel Li-ion system seems to be described by the following equation (1).

$$Ni_{0.8}Co_{0.2}OOH_{1-y}Li_y\cdot Li_x \quad \rightleftarrows \quad Ni_{0.8}Co_{0.2}OOH_{1-y} + (x+y)\,Li^+ + (x+y)\,e^- \quad (1)$$

This system is regarded as the high theoretical capacity from 591 mAh g^{-1} (y = 1) to 292 mAh g^{-1} (y = 0), when x equals 1.

References

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3) M. Kitano, T. Tabuchi, H. Yasuda, M. Yamachi, Y. Matsuda, and Y. Imai, The 44th Battery Symposium in Japan, 292 (2003).

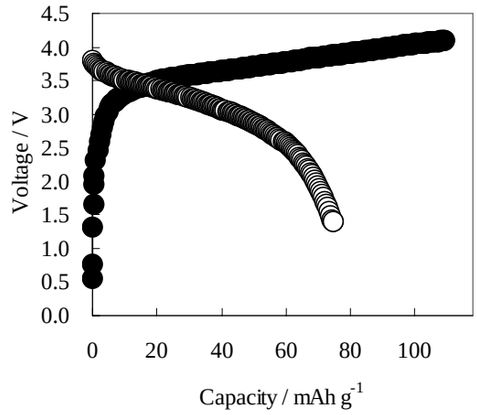

Figure 1 The initial charge-discharge characteristics of $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ / C system Li-ion laminate-type cell. Capacity is based on the mass of positive active material.

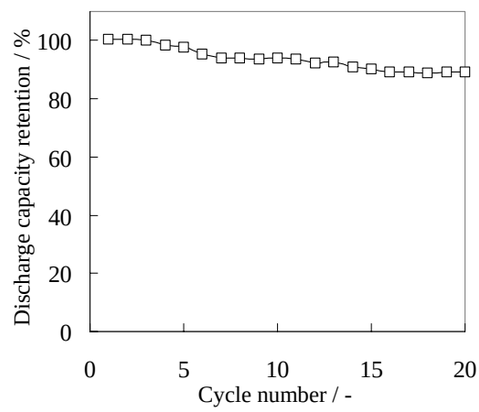

Figure 2 The discharge cycle performance of $Ni_{0.8}Co_{0.2}OOH_{0.43}Li_{0.57}\cdot Li_x$ / C system Li-ion laminate-type cell.