Rate Capability of Nano-size $LiCoO_2$ Cathode for Li-ion Cells

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Introduction

Currently, lithium-ion cells are widely used in many portable electric devices such as cellular phones and notebook computers. This is because of their longer cycle life and higher energy density than those of other rechargeable cells. However, their power density is not sufficient for use in electric vehicles. In the present study, the effect of $LiCoO_2$ particle size and cathode sheet thickness on the rate capability was investigated by using a Li / $LiCoO_2$ coin-type cell.

Experimental

We used four kinds of $LiCoO_2$ of different particle sizes (5□m, 25 nm, 23 nm in diameter, 5 (width)×60 (length) nm)[1]. $LiCoO_2$ powder was mixed with acetylene black (AB) (5 wt.%) and poly (vinylidene fuluoride) (PVdF) (5 wt.%) in N-methyl-2 pyrrolidinone (NMP) and stirred for 3 h. The slurry was then coated onto aluminum foil and dried. The cathode electrode of 1.5 cm in diameter was cut from the sheet. The cathode electrode was pressed and then dried at 110 ℃ under a primary vacuum. The dried cathode was transferred into an argon-filled dry box. A Celgard 3501 (Celanese Co) was used as a separator and lithium foil (Honjou Metal) was used as anode. The electrolyte used was 1M $LiPF_6$ in EC+DMC (1:1 in vol. %)(Tomiyama Pure Chemical Industries, LTD.). The cells were fabricated using a coin-type cell R2032. The cells were cycled galvanostatically at current densities ranging from 0.1 $mAcm^{-2}$ to 30 mA/cm^{-2}. The cycling voltage range was in the range of 2.6 V to 4.2 V.

Result and discussion

Three kinds of the electrodes of different thicknesses were made using $LiCoO_2$, which particle size is about 5 □m. Because the densities are nearly 1.36 g cm^{-3}, the porosities of the sheet electrodes were almost the same. As shown in Fig. 1, the capacity increased with the order of the thickness, 60□m < 40□m < 80□m, while nano-sized $LiCoO_2$ (25 nm, 23 nm, 5×60 nm) showed very large capacities compared with the5 □m $LiCoO_2$.

Figure 2 shows the discharge curves at 12 $mAcm^{-2}$. The nano-size $LiCoO_2$ showed a higher discharge voltage compared with the5 □m$LiCoO_2$.

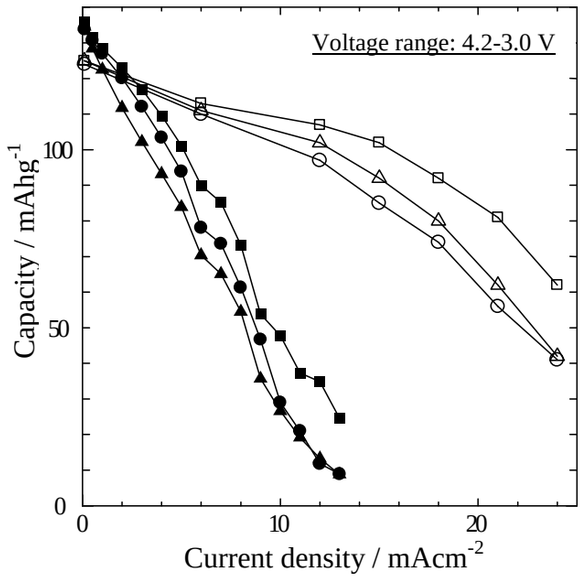

Fig. 1 Dependence of capacity on particle size of $LiCoO_2$
Electrode thickness and density are shown in parentheses.

● : Particle size: 5 μm (40 μm, 1.36 gcm^{-3})
○ : Particle size: 25 nm (80 μm, 1.60 gcm^{-3})
▲ : Particle size: 5 μm (60 μm, 1.36 gcm^{-3})
△ : Particle size: 23 μm (80 μm, 1.47 gcm^{-3})
■ : Particle size: 5 μm (80 μm, 1.41 gcm^{-3})
□ : Particle size: 5×60 nm (80 μm, 1.52 gcm^{-3})

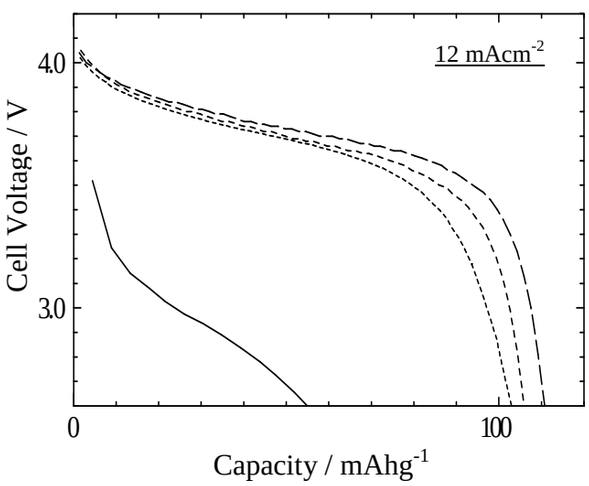

Fig. 2 Dependence of discharge curve on $LiCoO_2$ particle size.

Electrode thickness and density are shown in parentheses.

——— Particle size: 5 μm (80 μm, 1.41 gcm^{-3})
..... Particle size: 25 nm (80 μm, 1.60 gcm^{-3})
– – – – Particle size: 23 nm (80 μm, 1.47 gcm^{-3})
— — — Particle size: 5×60 nm (80 μm, 1.52 gcm^{-3})

Acknowledgement

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Reference

[1] T. Kawamura, M. Makidera, S. Okada, and J.Yamaki, Abstract of the 71th Meeting of The Electrochemical Society of Japan, March 26 2004 Yokohama p. 221.