Abs. 328, 206th Meeting, © 2004 The Electrochemical Society, Inc.

The Effect of Si Doping on the Electrochemical Characteristics of $LiNi_xMn_yCo_{(1-x-y)}O_2$

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Introduction

The cathode material is detrimental to the performance and safety of Li-ion batteries. Recently, Zhonghua Lu and D.D. MacNeil et, al.[1-5] reported that pure phase of $Li[Ni_xCo_xMn_{1-x-y}]O_2$ could be synthesize by using 'Mixed Hydroxide Method' and the synthesized material showed high capacity about 175mAh/g, good structural stability, and a good cycle life.

In this work, we invented a much more simple way to synthesize phase-pure $Li[Ni_xCo_xMn_{1-x-y}]O_2$ and improved its electrochemical properties by Si doping into the material.

Experimental

$LiNi_xMn_yCo_{(1-x-y)}O_2$ was synthesized by solution-base synthetic route. $Li(NO_3) \cdot H_2O$ (98+%, Aldrich), $Ni(NO_3)_2 \cdot 6H_2O$ (98+%, Aldrich), $Co(NO_3)_2 \cdot 6H_2O$ (98+%, Aldrich), $Mn(NO_3)_2 \cdot 4H_2O$ (98+%, Aldrich) and poly(methyl phenyl siloxane) (Aldrich) were used as the starting materials. A stoichiometric amount of Li, Ni, Mn, and Co nitrates was dissolved in high purity ethanol (99.9% Duksan). Into this, desired amount of poly(methyl phenyl siloxane) (2~10 mol% of total transition metal ions) was added and stirred for about 30min. The resultant solution was evaporated at open air at 70~80℃ to obtain pink-colored precipitate. The precipitate was pulverized and added with pure ethanol to turn the powder into mud-like state. This mud-like precursor was heat-treated at 450~500℃ for about 5 hours to obtain crude powder depleted of organic ingredients. The crude powder was grinded to fine powder and heat-treated at 600~650℃ for about 3hours and 900~950℃ for about 5hours successively.

Results and discussion

$LiNi_xMn_yCo_{(1-x-y)}O_2$ could be easily synthesized by solution-based synthetic route of this work. By making 'mud' of precipitates using ethanol to dissolve Li containing chemicals and intentional 3-step heat treatment, we could synthesize phase-pure $LiNi_xMn_yCo_{(1-x-y)}O_2$ without burdensome processes such as water washing, filtering, and repeated palletizing.

By the same synthetic method, Si could be easily doped into $LiNi_xMn_yCo_{(1-x-y)}O_2$ up to about 10 at% without any impurity phase formation. The Si-doped material showed enhanced cycle life and rate capability to the pure one. Those good effects of Si doping can be attributed to the increased lattice parameter and stabilized electrochemical impedance.

Acknowledgements

This research was supported by a grant (code #: NM02-2201-002-1-0-0) from 'Center for Nanostructured Materials Technology' under '21st Century Frontier R&D Programs' of the Ministry of Science and Technology, Korea.

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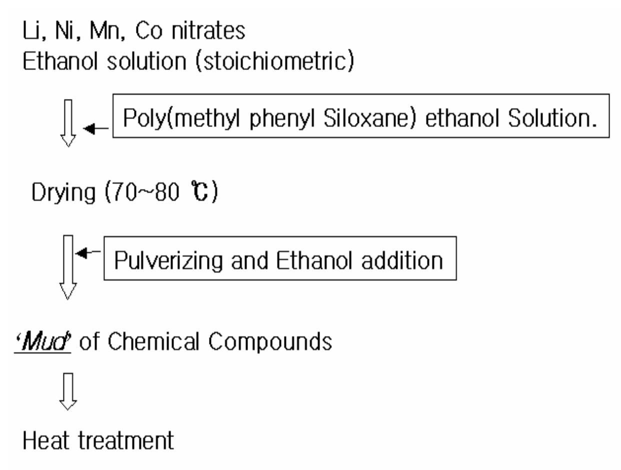

Fig.1 Synthetic route of .$Li[Ni_{1/3}Mn_{1/3}Co_{1/3}]_{0.96}Si_{0.04}O_2$

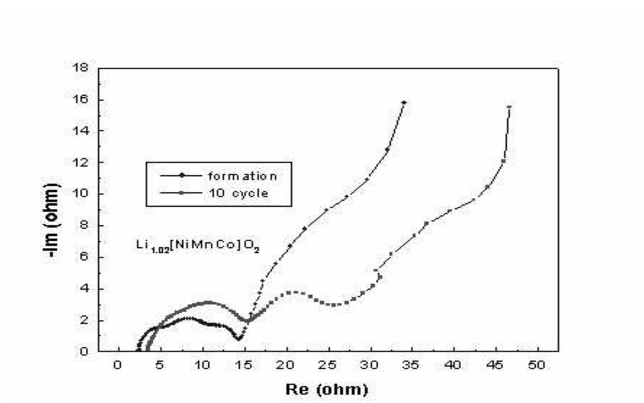

Fig.2 EIS change of pure $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ with cycling.

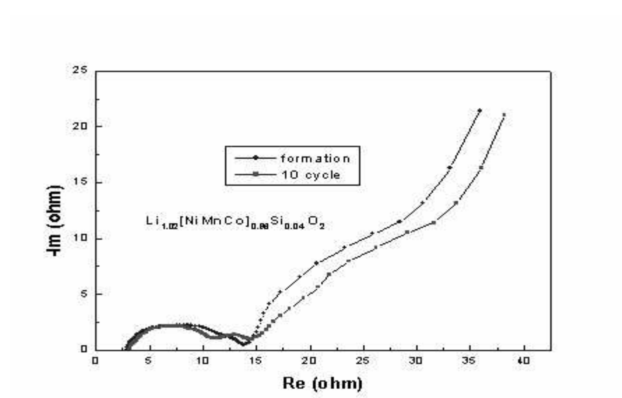

Fig.3 EIS change of $Li[Ni_{1/3}Mn_{1/3}Co_{1/3}]_{0.96}Si_{0.04}O_2$ with cycling