High-Performance Li-Rich Layered Transition Metal Oxide Cathode Materials for Li-ion Batteries

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Over the past few years, among the various candidates, high-performance Li-rich manganese-oxide cathode materials, denoted as $LiMnO_2$, are recognized as promising candidates for lithium ion batteries. Besides being highly abundant, inexpensive and nontoxic, layered oxide has high theoretical capacity (285 $mAh \cdot g^{-1}$), high operating voltage (~3 V vs. Li/Li^+) and high thermal stability in contact with commercial Li liquid electrolytes. On the cathode side the main limitation is structural instability of $LiMnO_2$ during the intercalation/deintercalation process and irreversible transformation to spinel $LiMn_2O_4$ structure that leads to the decrease of reversible capacity of the cell [1-2].
Simultaneous substitution of Mn by another transition metal (Ni, Co) and fabication of the layered-layered composite with the Li_2MnO_3 oxide, regarded as $xLi_2MnO_3 \bullet (1-x)LiMO_2$ (M= transition metals), seems promising method to reduce the capacity loss and improve structural stability of the $LiMnO_2$. Furthermore, fabrication the Li_2MnO_3-stabilized $LiMO_2$ (M = Mn, Co, Ni) composites results in significantly increased theoretical capacity (~400 mAh/g) and high operating voltage of ~4 V [3-4].
In our studies we have investigated several novel cathode materials, including $xLi_2MnO_3 \bullet (1-x)LiMO_2$ (M= Mn, Ni, Co). Composites were synthesized via sol-gel process and the results of the structural determination of the cathode materials from X-ray diffraction measurements and the refinement by the Rietveld technique are presented. The morphology of the obtained materials was investigated by means of Scanning Electron Microscope (SEM) technique. Thermogravimetric (TG) and Electrochemical Impedance Spectroscopy (EIS) measurements were also performed. To analyze the electrochemical properties, the $Li/Li+/xLi_2MnO_3 \bullet (1-x)LiMO_2$ (M= Mn, Ni, Co) charge/discharge tests were used.
The preliminary results of the electrochemical properties, both capacity and stability, are very promising in order to applicate them as cathode materials for lithium ion batteries.

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References:
[1] N. Yabuuchi, K. Yoshii, S.T. Myung, I. Nakai, S. Komaba, J. Am. Chem. Soc. 133 (2011) 4404
[2] J.T. Son, H.J. Jeon, J.B. Lim, Advanced Powder Technology 24 (2013) 270
[3] J. Li, S. Jeong, R. Kloepsch, M. Winter, S. Passerini, J. Power Sources 239 (2013) 490
[4] C.P. Grey, W.-S. Yoon, J. Reed, G. Ceder, Electrochem., Solid State Lett. 7 (2004) A290