Improving Electrochemical Performances of $0.25Li(Mn_{1.5}Ni_{0.5})O_4 – 0.75[Li_2MnO_3\text{-}Li(Mn_{0.5}Ni_{0.5})O_2]$ Cathode Materials for Lithium Secondary Batteries by ZrO_2 coating

Shin-Ho Kim, S. Amaresh, Jae-Youn An, Sol-nip Lee and Yun-Sung Lee*

Faculty of Applied Chemical Engineering, Chonnam National University, Gwangju 500-757, South Korea

*Tel : +82-62-530-1904, e-mail : leeys@chonnam.ac.kr

Mn-rich lithium metal oxides, such as the spinel $Li[Mn_{1.5}Ni_{0.5}]O_4$ and layered compounds within the system $Li[Mn_{2/3-\alpha/3}Ni_{\alpha}Li_{1/3-2\alpha/3}]O_2$ $(0 < \alpha < 1/2)$ are currently receiving significant interest as cathode materials for Li–ion batteries. The three-dimensional interstitial space provided by the $[M_2]O_4$ framework of a $Li[M_2]O_4$ spinel structure (e.g., M = Mn/Li, Ti/Li, Ni, Co) permits fast diffusion of lithium and design of electrodes with a high-rate capability, whereas layered electrodes in the $Li[Mn_{2/3-\alpha/3}Ni_{\alpha}Li_{1/3-2\alpha/3}]O_2$ $(0 < \alpha < 1/2)$ system can provide capacities greater than 200 mA h/g if initially charged to 4.6 V or higher. Hence there are many researchers focused their interest to investigate the possibility of integrating layered and spinel components for designing high capacity and high power electrodes with good cycling efficiency [1, 2].

In this regard, the current work is aimed on the improvement of electrochemical properties of spinel-layered cathode active material by applying a protective coating, namely ZrO_2. The spinel-layered-layered oxide $0.25\ Li(Mn_{1.5}Ni_{0.5})O_4–0.75\ [Li_2MnO_3\text{-}Li(Mn_{0.5}Ni_{0.5})O_2]$ material has been prepared by co-precipitation method. X-ray diffraction (XRD) showed that this material had mixed character of spinel and layered structure[1]. Scanning electron microscopy revealed that $0.25\ Li(Mn_{1.5}Ni_{0.5})O_4 – 0.75\ [Li_2MnO_3\text{-}Li(Mn_{0.5}Ni_{0.5})O_2]$ powders had uniform particle size distributions of 5μm. An effort has been attempted to enhance the electrochemical properties of $0.25Li(Mn_{1.5}Ni_{0.5})O_4 – 0.75[Li_2MnO_3\text{-}Li(Mn_{0.5}Ni_{0.5})O_2]$ active materials by protecting the surface with ZrO_2 coating of various mass percentages, which has been acting as a shielding layer between the cathode particles and electrolyte[3, 4]. Figure 1. showed that The final products obtained after ZrO_2 coating has no marked impurities as confirmed by XRD pattern. Figure 2. presents a remarkable change in the cycling behavior of the ZrO_2-coated $0.25Li(Mn_{1.5}Ni_{0.5})O_4 – 0.75[Li_2MnO_3\text{-}Li(Mn_{0.5}Ni_{0.5})O_2]$ samples with enhanced initial charge-discharge capacity, when operated between 2.0V and 4.95V vs Li at a current rate of $0.2mA/cm^2$. Synthesis methodology of ZrO_2 coated $0.25Li(Mn_{1.5}Ni_{0.5})O_4 – 0.75[Li_2MnO_3\text{-}Li(Mn_{0.5}Ni_{0.5})O_2]$ materials along with their physical, morphological and electrochemical characteristics will be discussed in detail.

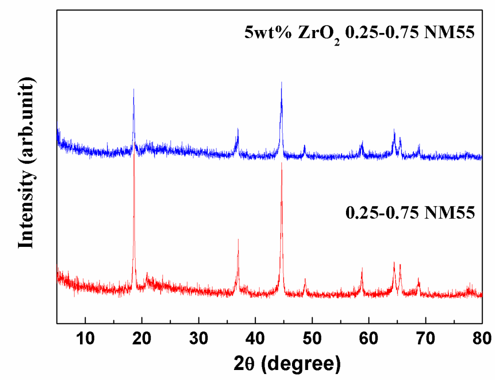

Fig. 1 XRD patterns of 5wt% ZrO_2 $0.25Li[Mn_{1.5}Ni_{0.5}]O_4$-$0.75\{Li_2MnO_3 \cdot Li[Mn_{0.5}Ni_{0.5}]O_2\}$

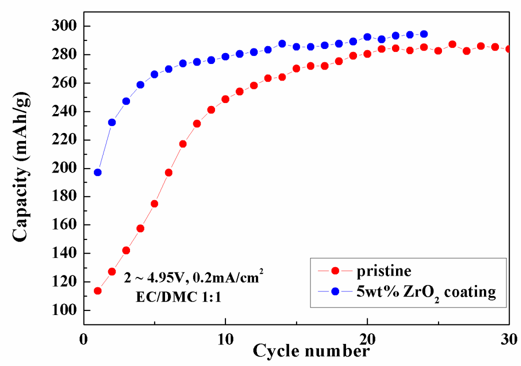

Fig. 2 Cycle ability of 5wt% ZrO_2 $0.25Li[Mn_{1.5}Ni_{0.5}]O_4$-$0.75\{Li_2MnO_3 \cdot Li[Mn_{0.5}Ni_{0.5}]O_2\}$

References

[1] S.H. Park, S.H. Kang, C.S. Johnson, K. Amine, M.M. Thackeray, Electrochemistry Communications. Vol. 9(2) (2007) 262-268

[2] E.S. Lee, A. Huq, H.Y. Chang, A. Manthiram, Chem. Mater., 24(3) (2012) 600-612

[3] J. Cho, T.J. Kim, Y.J. Kim, B. Park, Electrochem. Solid-State Lett., 4 (2001) A159-A161

[4] M.M. Thackeray, C.S. Johnson, J.S. Kim, K.C. Lauzze, J.T. Vaughey, N. Dietz, D. Abraham, S.A. Hackney, W. Zeltner, M.A. Anderson, Electrochem. Commun., 5 (2003) 752-758