Influence of lithium boron oxide coating on improved cycling stability in lithium-ion battery cathode

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Lithium-ion batteries with high energy density have a vital role as power sources, such as portable devices and electric vehicles. The demand for higher capacity has grown recently to extend the drive range of electric vehicles. $Li[Ni_{0.5}Co_{0.2}Mn_{0.3}]O_2$ (NCM) has been considered to be one of the most promising cathodes because it has a higher discharge capacity than currently used $LiCoO_2$ and $Li[Ni_{1/3}Co_{1/3}Mn_{1/3}]O_2$. However, high contents of Ni and high cutoff voltages result in unstable cycle performances. Studies in the literature have so far revealed several important factors for the capacity fade, which include the transition metal cation dissolution from the active material into the electrolytes, the decomposition of the electrolytes through side reactions of $LiPF_6$ with water molecules, and the crack formation in the secondary particles. One effective approach is to modify the surface of NCM with various oxides. They revealed that the surface modification suppressed the dissolution of transition metal cation as well as the decomposition of the electrolytes at high potentials. Spray pyrolysis is a simple one-step synthesis technique to obtain various kinds of functional oxide powders including cathode materials [1]. Recently, we have confirmed that no micro-cracks are detected in the NCM particles after the cycling because these secondary particles have a small size.

In this study, we coated spray pyrolyzed $Li[Ni_{0.5}Co_{0.2}Mn_{0.3}]O_2$ with lithium boron oxide (LBO) and investigated the charge and discharge properties of the cathodes. LBO-NCM powders were prepared via a precipitation method; synthesized NCM powders were suspended in distilled water containing 2 or 5 wt.% of $LiBO_2$. Ethanol was added drop-wisely to the suspension with vigorous stirring. The precipitation was filtered, dried, and annealed at 500 ^oC to obtain LBO-NCM powders.

The coating layer was observed on the surface of the LBO-NCM powders by transmission electron microscopy, and a boron component was detected in the LBO-NCM powder by X-ray photon spectroscopy. The capacity retention of the LBO-NCM samples was much higher than that of the non-coated NCM sample, so the cycling stability of NCM was improved by lithium boron oxide coating layer. Nyquist plots of the LBO-NCM sample showed smaller impedance than that of the NCM sample. These resluts suggested that the lithium boron oxide coating prevented the direct contact between the cathode and the electrolyte, and therefore suppressed side reactions.

References:

[1] S. Hashigami, M. Kawanishi, K. Yoshimi, S. Ujiie, T. Inagaki, M. Hashinokuchi, T. Doi, M. Inaba, *Electrochemistry*, 84(11), 842 (2016).