Advanced Nano-Composite Lithium-Metal-Oxide Electrodes for High Energy Lithium-Ion Batteries♣

Sun-Ho Kang and Michael Thackeray

Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439
sunho.kang@anl.gov

ABSTRACT

Layered lithium cobalt oxide ($LiCoO_2$) and nickel-substituted derivatives are the most widely used positive electrode materials in lithium-ion batteries. However, their limited capacity (150-160 mAh/g), thermal instability in the charged state and the recent global interest in lithium-ion batteries for electrically-powered vehicles have emphasized the need to develop advanced cathode materials that will offer higher energy and improved safety. In efforts to develop advanced cathode materials for high energy cells, we have adopted a unique approach of integrating lithium metal oxides in nano-composite structures, examples of which are: (1) 'layered-layered' electrodes with layered Li_2MnO_3 ($Li_{1.33}Mn_{0.67}O_2$) and $LiMO_2$ (M=Ni,Co,Mn) components, represented generically as $xLi_2MnO_3 \bullet (1-x)LiMO_2$ and (2) 'layered-layered-spinel' electrodes comprised of layered Li_2MnO_3, layered $LiMO_2$ and spinel LiM'_2O_4 (M′=Ni, Mn) components. These cathode materials deliver a capacity in excess of 200 mAh/g and they provide a high-voltage stability (>4.4 V vs. Li^+/Li); they also possess superior thermal stability over $LiCoO_2$ and $LiCo_{1-x}Ni_xO_2$ electrodes due to their high Mn content. The structural compatibility of Li_2MnO_3 with layered $LiMO_2$ and spinel LiM'_2O_4 materials, which is a consequence of their common cubic-close-packed oxygen arrays, allows the integration of the Li_2MnO_3-$LiMO_2$- and spinel LiM'_2O_4 components at the atomic level. A detailed account of the electrochemical and structural properties of these highly complex nano-composite materials, as determined by various experimental techniques, such as NMR, TEM, X-ray diffraction and absorption, will be presented.

Acknowledgments

This work was supported by the Office of Vehicle Technologies of the U.S. Department of Energy.
