SPINEL OXIDE BASED ELECTRODE MATERIALS FOR HIGH ENERGY AND HIGH POWER DENSITY RECHARGEABLE LITHIUM ION CELLS

ABSTRACT

A pouch cell fabrication facility has been developed to study the electrochemical characteristics of Meso Carbon Micro Beads (MCMB) // Lithium Manganese Nickel Oxide (LMNO-$LiMn_{1.5}Ni_{0.5}O_4$), MCMB // $0.5Li_2MnO_3 \bullet 0.5Li(Mn_{0.375}Ni_{0.375}Co_{0.25})O_2$ (LL), MCMB // $0.5[0.5Li_2MnO_3 \bullet 0.5Li(Mn_{0.375}Ni_{0.375}Co_{0.25})O_2] \bullet 0.5LiMn_{1.5}Ni_{0.5}O_4$ (LL-S-50), Lithium Titanium Oxide ($Li_4Ti_5O_{12}$-LTO) // LMNO, LTO // LL based Li-ion rechargeable cells. The electrode materials (LTO, LMNO, Composite-LL and LLS-50) were up scaled using an economic, wet chemical synthesis route. Four strategies namely engineering of the surface morphologies, addition of aliovalent dopants, particulate surface coating and making composites with reduced graphene oxide have been adapted to improve the electrochemical characteristics of electrode materials. We have reported that LMNO cathode with optimized surface morphology exhibits discharge capacity ~ 126 mAh/g and capacity retention ~ 116 mAh/g after 50 cycles (at 14.7 mA/g, i.e., 0.1C rate). 4.0 at% Al doped LMNO yielded 130 mAh/g discharge capacity and ZnO coated 4.0 at% Al doped LMNO delivered 130 mAh/g capacity. Ru doped LMNO at 5 at% yielded 124 mAh/g with better cycleability and rate capability (95 mAh/g at 10C rates). This composition also yields energy density ~570 and ~533 mWh/g at 1^{st} and 50^{th} cycle respectively. Through X-ray diffraction measurements, in conjunction with HRTEM, we have elucidated the nature of structural integration of layer - layer $[0.5Li_2MnO_3 \bullet 0.5Li(Mn_{0.375}Ni_{0.375}Co_{0.25})O_2]$ composites with $LiMn_{1.5}Ni_{0.5}O_4$ spinel to make higher capacity integrated cathode. Layer-layer composite and spinel integrated layer-layer composite (LL-S-50) delivered 240 mAh/g and 170 mAh/g respectively. To the best of our knowledge, electrochemical capacity of MCMB // LMNO, MCMB // LL, MCMB // LL-S-50, LTO // LMNO, and LTO // LL in pouch cell configuration has hardly been reported. In the present, work we have reported decent discharge capacity (~300 mAh; estimated nominal capacity was 350 mAh), capacity retention (~ 79% after 50 cycles) and rate performance (300 mAh @ C/4 and 240 mAh @ C/3) in MCMB // LMNO pouch cell. Finally, we have claimed that both MCMB // LMNO and MCMB // LL full cell hold promises for high energy and high power density Li-ion cells whereas LTO // LMNO and LTO // LL for high energy and long life Li-ion cells for under water applications.

Keywords: Spinel oxide, high energy & high-power density, composite cathode, Li-ion pouch cells.