Improving the stability of $LiNi_{0.5}Mn_{1.5}O_4$ as a high-power cathode material for Li-ion batteries by MgO coating

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$LiNi_{0.5}Mn_{1.5}O_4$ (LNMO) has been considered as a promising cathode material for lithium ion batteries due to its high open-circuit voltage (~4.7 V vs. Li^+/Li^0) and reasonable capacity. The low cost, low toxicity, easy preparation and high safety characteristics make it a promising candidate for automotive application. However, this spinel suffers a quick capacity fade when utilized in a secondary battery system, which is mainly contributed by the presence of Mn^{3+} and the dissolution of Mn^{2+} in non-aqueous electrolyte from the disproportionation reaction of Mn^{3+}, and electrolyte oxidization by LNMO.(1, 2) Coating a passivating layer on the surface of LNMO to suppress the side reactions is a common method used for this material in order to improve the cycling and structural stability.(3)

In this report, MgO was employed as a protection layer coated on the LNMO to improve the stability of LNMO, and consequently, to enhance the capacity retention. $LiNi_{0.5}Mn_{1.5}O_4$ were fabricated by a coprecipitation method using lithium hydroxide, nickel sulfate and manganese sulfate. The precipitation was then washed, tried and annealed at 900 °C for 1 hour to achieve the spinel structured LNMO.(4) MgO coated LNMO samples were obtained by dispersing LNMO power in a magnesium containing solution followed by proper heating treatment. Two different annealing temperatures, 500 and 800 °C, were chosen to evaluate the effect of temperature on coating. The morphology of coated samples were investigated by electron scanning microscopy (SEM) shown in Figure 1. MgO segregations can be found on the surface of the 500 °C sample, while the 800 °C sample has clean surfaces and homogeneous Mg distribution based on the energy dispersive X-ray spectroscopy analysis. The local chemical environment of Ni, Mn, and oxygen were studied by X-ray absorption and photoelectron spectroscopy. Electrochemical properties of the MgO coated samples were investigated at both room temperature and elevated temperature, 50 °C. Coulombic efficiency of LNMO and 500 and 800 °C MgO coated LNMO tested at 50 °C are shown in Figure 2. A significant improvement of the Coulombic efficiency was achieved by MgO coating, which indicates that the cycling performance was improved by MgO coating, especially, at 50 °C. More spectroscopy and electrochemical characterizations and detailed discussion will be presented.

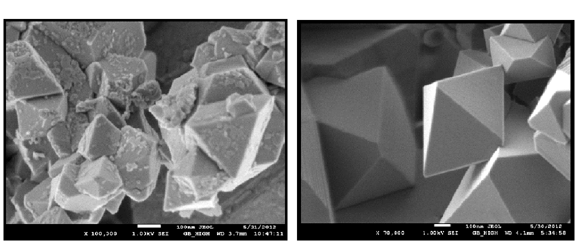

Fig. 1: SEM image of LNMO samples coated with MgO annealed at a) 500 °C and b) 800 °C. The scale bar is 100 nm.

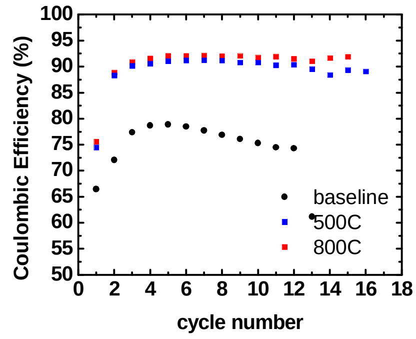

Fig. 2: Coulombic efficiency of uncoated $LiNi_{0.5}Mn_{1.5}O_4$ and LNMO MgO coated, annealed at 500 °C and 800 °C at 50 °C.

References

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