Development of High capacity cathode materials for lithium ion batteries

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The awareness about limited fossil fuels has led to promote research into the areas of alternative energy production, **storage,** and distribution systems. It is well accepted that lithium batteries are among the most promising technologies to meet the energy storage needs for regenerative energy use. Despite considerable efforts to tune lithium-ion batteries, already well-established in the consumer goods market, efforts are going on for large scale applications such as solar energy storage, electric vehicles (EVs) and hybrid electric vehicles (HEVs).

Lithium-ion batteries (LiBs) are generally composed of two electrode compounds having an open structure, which act as host frameworks for the insertion/de-insertion of Li^+ ions and are the place of charge transfer. Usually, the LiB prototype consists of graphite or another suitable anode material as a negative electrode (anode) and a transition-metal oxide (TMO), i.e., $LiCoO_2$, $LiMn_2O_4$, $LiFePO_4$ etc., as a positive electrode (cathode) and separated by the electrolyte which provides a transport medium for ions. During the charging, the LiB charges, the Li^+ ions are extracted from the cathode and inserted into the anode, while the electrons pass through the outer circuit (load). Consequently, the effectiveness of a lithium-ion cell is dependent on the availability of sites for hosting Li^+ ions, in other words on the insertion mechanism and thereby on the transport properties of ions and electrons especially, in cathode materials.

In the case of LiB with the graphite/TMO configuration, the limiting factor comes from the cathode side. As the transition metal entering the composition of the active element of the cathode is oxidized and reduced during the cell charge and discharge, respectively, the cathode is primarily involved in the cathode process and then in the electrochemical performance parameters of the cell, i.e., potential, specific capacity, energy density, rate capability, etc. Achieving high rate rechargeable Li-ion batteries depends ultimately on the cathode and dimension of the active particles for both negative and positive electrodes. One of the prospective solutions for the preparation of cathodes with high capacity, energy and power density is to use novel nanosize $Li(Ni_xMn_yCo_{1-x-y})O_2$ (NMC) cathodes (coated as well as non-coated), which are capable of delivering high reversible capacity and have layered rhombohedral structures. These materials are now widely studied as alternative 4-volt cathode materials to replace $LiCoO_2$, exhibiting much higher voltage, great structural stability, and enhanced safety even at elevated temperature and higher reversible charge capacity. In the present paper, results on high capacity cathodes, especially, NMC cathodes will be discussed.