Synthesis and evaluation of core/shell structured NMC cathode material

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Cathode materials are the main elements of the Li-ion batteries and determine their key performing characteristics, including power and energy density values, cell voltage, capacity and cycle life. Up to date, Lithium-Nickel-Manganese-Cobalt-Oxide (so-called NMC) remains the most successful formulas for cathode powder, delivering strong overall performance and excellent specific energy. Within these compositions, Nickel provides high energy density and increased storage capacity at lower cost and contributes to the circular economy due to the durability, recyclability and possible second life. Therefore, Ni-rich composition, NMC 811, is more preferentially used in high performance batteries. However, the formation of the Ni^{2+} phase during the successive charge/discharge cycles resulting in Ni-oxidation causes chemical and structural degradation and thus, deteriorates the cyclic performance. On the other hand, Manganese in NMC composition acts not only as a stabilizer, but also, prevents Nickel-oxidation and thus, reduces the risk of capacity fading. Regarding these facts, development of core/shell structured NMC morphologies deserved a special attention. This morphology provides surface stabilization of Ni-rich NMC by keeping the energy storage capabilities at higher level and prevents degradation of cathode.

In this work, we describe an oxalate-assisted co-precipitation route for synthesis of core/shell structured NMC cathode particles. For achievement of core and shell in different compositions, two-staged wet-chemical synthesis approach was applied. It is well known that morphology is affected strongly by synthesis parameters, therefore the influence of solvent type, co-precipitation temperature, stirring speed, reaction time and sintering parameters was studied in accordance with electrochemical performance testing. Li incorporation was carried by two approaches; top-down and bottom-up methods. Identification of the compositional and structural relations within the core/shell particles, SEM, TEM, FIB and XRD techniques were used. Electrochemical characterization indicated that Li infiltration process and parameters of heat treatment play a significant role in achievement of good cathode performance.