Synthesis and Evaluation of $LiNi_{0.5}Mn_{1.5}O_4$ Particles by Aerosol Spray Pyrolysis for Next -generation Li-ion Cathode Materials

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Rapid advancement of technologies for production of next-generation Li-ion batteries will be critical to address the requirements for clean, efficient and secure transportation by EVs (Electric Vehicles) and PHEVs (Plug-in Hybrid Electric Vehicles) (Goodenough, 2010). The challenge of bringing high voltage (5V) cells into the market calls for advancements in key components such as the electrolyte, anode and cathode materials and their interaction by sophisticated cell design by improving the electrodes in terms of energy density, power density and cycle life. Current work discusses the synthesis of $LiNi_{0.5}Mn_{1.5}O_4$ particles by aerosol spray pyrolysis in order to study their nanostructure by exploiting their characteristics towards crystal structure, particle size, morphology, surface area and pore size distribution and their effect on the electrochemical performance.

The synthesis parameters which have been exploited in order to study their effect on the particle nanostructure are the chemistry and concentration of the precursor solution, the synthesis temperature in the tubular reactor and post calcination temperature profiles of the collected particles, while the particles were synthesized both in a lab scale reactor for primary evaluation and a pilot scale reactor for large production quantities for cell assembly.

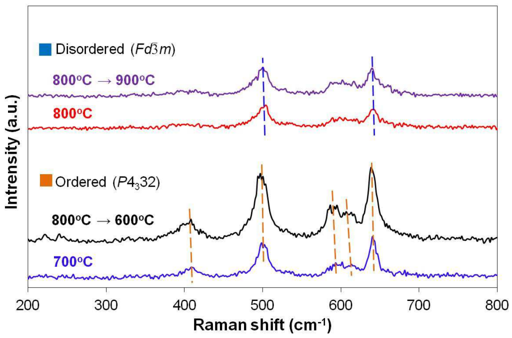

Figure 1. Raman spectra for the $LiNi_{0.5}Mn_{1.5}O_4$ calcined at different temperature profiles exhibiting the ordered and disordered phase

The precursor solution chemistry and reactor operating conditions were adjusted in order to obtain the $LiNi_{0.5}Mn_{1.5}O_4$ structure, while the post-calcination profile conditions of the collected powder were studied in order to obtain the two main spinel phases: the ordered ($P4_332$) and the disordered ($Fd3m$), which affect the electrochemical activity of the material. The temperature profiles which have been studied vary from 700-900ºC, with the temperatures over 700ºC leading to the disordered phase and larger crystallite sizes, while a second calcination step below 700ºC formed the ordered structure again. The $LiNi_{0.5}Mn_{1.5}O_4$ phase was determined by micro-Raman spectroscopy (Renishaw® inVia™ Raman microscope) and the results for different temperatures are depicted in Figure 1.

The same synthesis conditions have been applied to both lab and pilot scale reactors where, in the latter case, the formation of a denser aerosol has led to the formation of a different particle morphology, due to the lower evaporation rate. The morphology of the $LiNi_{0.5}Mn_{1.5}O_4$ particles as exhibited in Figure 2, is spherical with various porosity formation depending on the calcination profile.

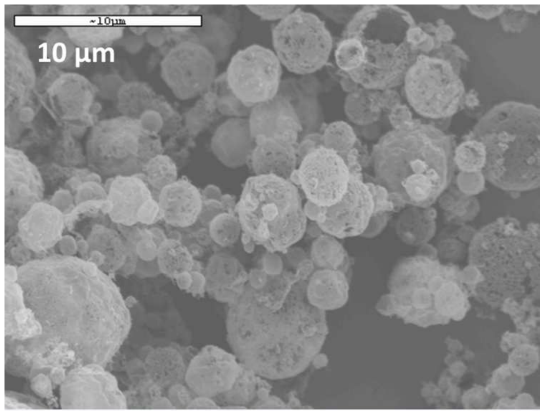

Figure 2. SEM image of the $LiNi_{0.5}Mn_{1.5}O_4$ particles synthesized by the pilot scale reactor

Significant differences have been identified during the electrochemical performance characterisation for the ordered and the disordered phase.

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