Effect of manufacturing conditions on the efficacy of $NaNi_{1/3}Mn_{1/3}Fe_{1/6}M_{1/6}O_2$

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With both the ethical and financial pressures placed upon the lithium and cobalt markets, sodium ion batteries are being considered as a replacement for lithium ion battery systems. In particular, the O3 nickel layered oxide systems have shown promise in terms of the voltage and specific capacities, and may start to rival some of the lithium ion chemistry systems.[1,2] The efficacy of the layered oxides for both Na and Li has been found to be reliant on several factors, both chemical and physical in nature. These include, but are not limited to: Cation diffusion path length, particle size, agglomerate size, morphology, synthesis method; time and temperature.[3]

By performing an in depth analysis on the effect of the manufacturing processes on crystal structure, capacity, cycle life, and first cycle losses, it is possible to target certain structural-property relationships in these novel materials. This facilitates the targeting of future cathode compositions with improved property relationships. An approach such as this provides a benchmark against which to compare the true performance properties of these novel materials in order to determine, at a glance, how these materials may compare to industry-leading cell chemistries.

This study details the comparisons between $NaNi_{1/3}Mn_{1/3}Fe_{1/6}Ti_{1/12}Mg_{1/12}O_2$ (Na-NMF) which has been manufactured by two different synthesis methods: a low cost precipitation method and solid state synthesis method. The synthesis mechanism was elucidated and the final materials optimised for volumetric and gravimetric capacities.

To this end, materials of interest were characterised prior to their assembly into cells (Na-NMF/Na and Na-NMF-Hard carbon), using a variety of techniques, such as: DLS, SEM-EDX and XRD, and their electrochemical performances were compared. The volumetric and gravimetric capacity of cells was estimated using Batpac©. Furthermore, air stability studies were performed on the as produced materials to determine the suitability of using the standard manufacturing methods of lithium-ion batteries for these materials.

The co-precipitation method produced materials which show superior specific capacities and higher voltages upon discharge. In comparison, the solid state synthesis method produced high tap density materials which packed better into an electrode. Due to the higher specific capacities and voltages, the co-precipitation materials exhibited superior properties despite the poorer tap densities of the material.

References:

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