Extending the life-span of O3-type layered oxide cathode enabled by the nanoscale aluminum oxide coating for high-energy density sodium-ion batteries

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Sodium-ion batteries (SIBs) appear to be a promising alternative due to the abundance of sodium in the Earth's crust. [1] Also, the chemistry of SIBs is similar to that of well-established lithium batteries, which adds additional merit. So far, various chemical compositions have been introduced through different transition metal substitutions (Ni, Co, Mn, and Fe) such as $Na[Ni_xFe_yMn_z]O_2$ or Na[NixCoyMnz]O_2 compound. [2-4] However, the O3-type layered oxides in SIBs exhibit a low reversible capacity and poor cycle retention due to the structural instability that arises from multi-phase transitions.

A surface-modified O3-type $Na[Ni_{0.6}Co_{0.2}Mn_{0.2}]O_2$ cathode was synthesized by Al_2O_3 nanoparticle coating using a simple dry ball-milling route. The nanoscale Al_2O_3 particles (15 nm in diameter) densely covering the spherical O3-type $Na[Ni_{0.6}Co_{0.2}Mn_{0.2}]O_2$ cathode particles effectively minimized parasitic reactions [5] with the electrolyte solution while assisting Na^+ migration. The proposed Al_2O_3 coated $Na[Ni_{0.6}Co_{0.2}Mn_{0.2}]O_2$ cathode exhibited a high specific capacity of 151 mA h g^{-1}, as well as improved cycling stability and rate capability in a half cell. Furthermore, the Al_2O_3 coated cathode was scaled up to a pouch-type full cell using a hard carbon anode that exhibited a superior rate capability and capacity retention of 75% after 300 cycles with a high energy density of 130 W h kg^{-1}. In addition, the postmortem surface characterization of the cathodes from the long-term cycled full cells helped in identifying the exact mechanism of the surface reaction with the electrolyte and the reason for its subsequent degradation and showed that the nano-scale Al_2O_3 coating layer was effective at resolving the degradation pathways of the cathode surface from hydrogen fluoride (HF) attack.

References:

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