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Coating as a potent method to enhance the specific capacity, charge rate and cycle life of cathodes for next-generation Li-ion batteries

$LiCoO_2$ is the major cathode material for Li-ion batteries (LIBs) since 1992 because it excels in many electrochemical properties. However, recent research efforts have been devoted to the development of $Li(NixMnyCoz)O_2$ where x + y + z = 1 (NMC) because of the high price of Co and the high specific capacity from NMCs. In spite of their cost and capacity advantages, NMCs exhibit significant capacity decay during charge/discharge cycles. It is found that most of the capacity decay mechanisms start at the particle surface. As a result, proper coatings can improve the cycle stability of NMCs. With this in mind, we have investigated a new wet-chemical method to coat nano-$LiCoO_2$ (LCO) particles and micro-$Li(Ni_{0.5}Mn_{0.3}Co_{0.2})O_2$ (NMC532) particles. In this newly-developed wet-chemical method, $Al(NO_3)_3$ is used as the Al source to form Al_2O_3 and $LiAlO_2$, whereas $LiNO_3$ is used as a sacrificial agent to protect LCO and NMC particles and at the same time to form $LiAlO_2$ by reacting with Al_2O_3. Addition of $LiNO_3$ into the $Al(NO_3)_3$ coating solution suppresses the unwanted formation of Co_3O_4 during the coating process and leads to a thin (5–10 nm) and continuous $LiAlO_2/Al_2O_3$ coating. $LiAlO_2/Al_2O_3$-coated nano-LCO exhibits an unusually high initial specific capacity of 225 mA hg^{-1}, while micro-LCO can only deliver a specific capacity of 145 mA hg^{-1}. For NMC532, the initial specific capacity has been increased from ~160 mA hg^{-1} to above 200 mA hg^{-1}. In addition, the charge/discharge cycle stabilities of both LCO and NMC532 have been improved substaintially. Furthermore, the rate capabilities of both LCO and NMC532 have been enhanced as well. The unusually high specific capacity and superior capacity retention for long cycle life at high rates for both $LiAlO_2/Al_2O_3$-coated LCO and NMC532 are attributed to the effectiveness of $LiAlO_2/Al_2O_3$ coating in preventing capacity decay during battery soaking as well as during cycling. The principle and methodology of this newly-developed wet-chemical coating method are applicable to other layered transition metal oxide cathodes and can open up new opportunities to obtain superior electrochemical properties from these advanced cathodes in the near future.

Speaker Biography

Leon L Shaw is Rowe family endowed Chair Professor in sustainable energy and professor of Materials Science and Engineering at Illinois Institute of Technology (IIT), Chicago, USA. His main research interest is in nanomaterials synthesis and processing for energy storage and structural applications. In the arena of energy storage, his research team has worked on various anode and cathode materials for Li-ion batteries, Na-ion batteries, supercapacitors, and hybrid redox flow batteries over the last decade. He has authored and co-authored more than 290 archival refereed publications with 8,000 plus non-self citations (according to Google Scholar). He is a Fellow of ASM International, a Fellow of the World Academy of Materials and Manufacturing Engineering, Poland, and a member of the Connecticut Academy of Science and Engineering.

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