Cobalt-free Oxide Cathodes for High Energy Density Lithium Batteries

Arumugam Manthiram
Department of Mechanical Engineering
The University of Texas at Austin
Austin, TX 78712, USA

Lithium-ion batteries have become an integral part of our daily life, powering portable electronic devices and electric vehicles. They are also intensively pursued to efficiently and economically store and utilize electricity produced from solar and wind energies. As we move forward with vehicle electrification and renewable energy storage, various factors, such as cost, energy density, power density, cycle life, safety, and environmental impact, need to be considered and balanced in designing next-generation materials and battery chemistries. Among them, cost along with sustainability and supply chain issues will be the single most dominant factor as the large-scale energy storage market is exponentially expanding. In lithium-ion batteries, the cathode comprises 50% of the materials cost as they contain expensive and scarcely available metals like cobalt. This presentation will focus on reducing and then eliminating cobalt altogether from layered oxide cathodes, while also increasing the energy density. This is accomplished by increasing the nickel content in the cathode and replacing graphite anode with lithium-metal anode. However, increasing the nickel content to > 80 % results in severe cycle, thermal, and air instability, while lithium-metal anode suffers from cycle life limitations. The understanding gained on the bulk and surface degradation mechanisms with advanced characterization of the electrodes after large number of charge-discharge cycles and the approaches to overcome the challenges will be presented. The critical role of electrolytes and design of electrolytes that are compatible with both high-nickel cathodes and lithium-metal anode will be covered.