Spent Lithium Manganese Oxide (LMO) Cathode Materials as Precursors for High Capacity Li-ion Battery Cathodes

S. Dube and T. Moyo-Mahlangu

The Pennsylvania State University

Abstract

Recycling spent lithium−ion batteries is essential for addressing resource scarcity and minimizing environmental impacts. Spent lithium manganese oxide (LMO) cathodes, commonly found in consumer electronics and energy storage systems, present a valuable resource for recycling. This study presents an innovative approach for upcycling spent lithium manganese oxide (LMO) into high-performance lithium nickel manganese cobalt (NMC) oxide cathodes, which offer high energy density and longer cycle life. The recycling strategy involves hydrothermal re-lithiation and controlled selective doping with nickel and cobalt, transforming the manganese-rich structure into a stable NMC framework. The influence of reaction parameters on the recycling efficiency of the hydrothermal method and their impact on the morphology are studied. Characterization techniques including X-ray diffraction (XRD), inductively coupled plasma (ICP) analysis, and transmission electron microscopy (TEM) confirm the transformation of the LMO phase into NMC structure. NMC cathode materials exhibit improved energy densities, enhanced cycling stability, and capacity retention. Electrochemical tests including cyclic voltammetry and charge-discharge analysis determine the discharge capacity, and cyclic stability of the recycled materials. By utilizing spent LMO as a precursor, the proposed process contributes to a circular economy, promoting the reuse of battery materials in a sustainable manner. Recycling LMO into NMC is a viable solution for extending material life cycles and optimizing resource utilization in the lithium-ion battery supply chain.