Hybrid Power-Energy Electrodes

Roberto Colombo

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Summary

My Ph.D. research primarily concentrated on two main topics in the field of battery materials: (I) the synthesis and characterization of high-energy hybrid cathode materials for lithium-sulfur batteries, and (II) the formulation of high-voltage, cobalt-free cathodes for lithium-ion batteries.

Chapter 2 offers a detailed examination of lithium-ion batteries, covering their working principle and the critical parameters defining Li-Ion batteries. This section also investigates the variety of materials used in these batteries, particularly focusing on those used in cathodes.

Chapter 3 focuses on lithium-sulfur batteries, outlining their operational principles and the notable challenges this technology faces, alongside potential advantages over conventional lithium-ion batteries. It also focuses the development of cathode materials, which is a critical for advancing lithium-sulfur battery technology.

Chapter 4 discusses High Entropy Oxides (HEO), beginning with an overview of the material and its applications in Li-S batteries. It then describes the material's synthesis methods and its physicochemical characterization, continuing with the production of sulfur-based electrodes and their electrochemical testing.

Chapter 5 explores a composite material constisting of reduced Graphene Oxide and Zinc Sulfide nanoparticles, designed to be used as cathode material for lithium-sulfur batteries. Following the introduction of the material, the chapter details the synthesis method, followed by the physicochemical and electrochemical characterization of cathodes, which involves sulfur infiltration into the rGO-ZnS matrix.

Chapter 6 diverges from previous discussions by focusing on two cathode materials for Li-Ion batteries, LNMO and LFP. These materials are thoroughly described from structural and electrochemical perspectives. The chapter concludes with the production and full characterization of cathodes from a blend of these materials.

The final chapter describes the development and study of a high-voltage cathode material for Li-Ion batteries, lithium copper manganese oxide (LCMO). This involved a chemical over-lithiation process to enhance the lithium content in the material, which was then tested in both half-cell and full-cell configuration. This part of my research was conducted in collaboration with the Commissariat à

l'énergie atomique (CEA) of Grenoble, where I spent 6 months during my second doctoral year.
The final chapter concludes the dissertation by summarizing the research findings and outlining future directions for Li-Ion and Li-S battery research. It reviews the work carried out during the PhD and identifies potential areas for further investigation.