Process Development and Scale-Up of Sodium-ion Cathode Materials

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Topic: Sodium Batteries
Vertical: Materials and Systems Innovation
Strategic Pathways: Grow
Project start date: FY24 -FY25

Background

Introduction

Sodium-ion batteries have emerged as a promising energy storage technology due to the low cost of sodium resources. Developing scalable manufacturing methods for advanced cathode materials is critical to improving battery performance, reducing cost, and supporting sustainable energy technologies

Current Research Status

Battery-grade materials are essential for achieving performance required in real-world applications. This require precise control over morphology, particle size distribution, composition, and tap density. Our material ($Na_xMn_{0.5}Ni_{0.4}Fe_{0.1}O_2$) has shown outstanding performance but is not commercially available, limiting access and deployment. Establishing in-house synthesis capabilities at PNNL will ensure reliable material production, improve quality control, and enable systematic optimization for research, development, and scale-up.

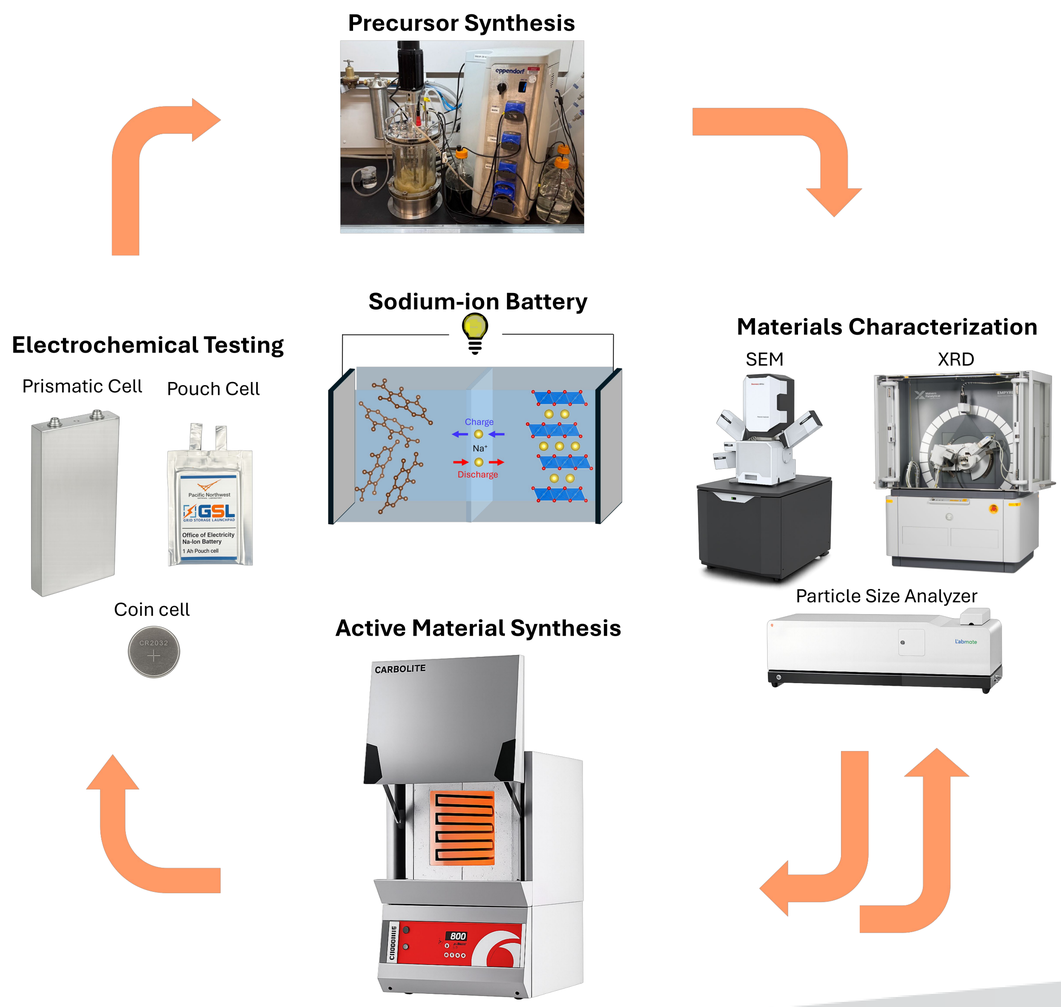
Project Objective

- ❑ Develop process to produce dense spherical with controlled composition, particle size and morphology
- ❑ Understand relationship between precipitation conditions and cathode performance
- ❑ Improve reproducibility and scalability of precursor manufacturing

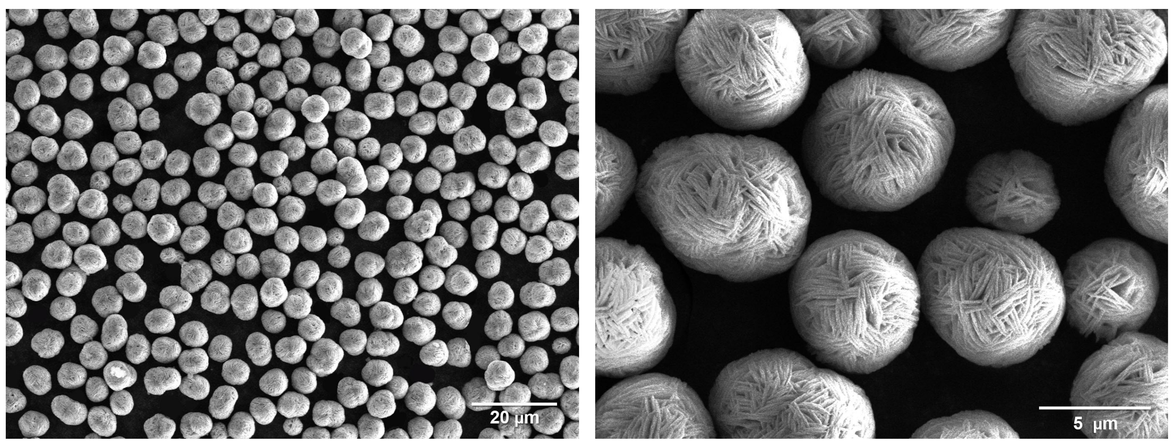
Approach

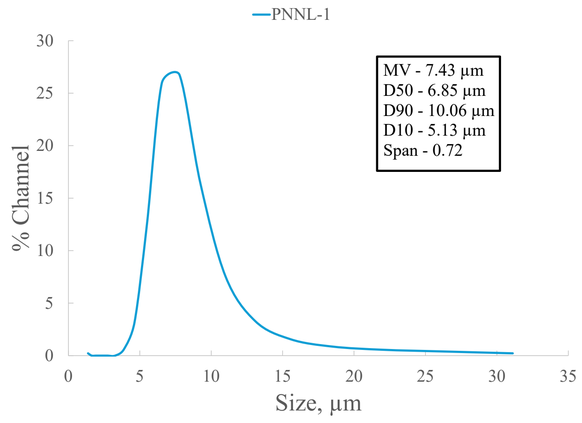
A continuous wet-precipitation synthesis in continuously stirred tank reactor (CSTR) process integrates precursor synthesis, cathode fabrication, and electrochemical testing, enabling rapid optimization of sodium-ion cathode materials through direct performance feedback.

Closed Loop Development Framework



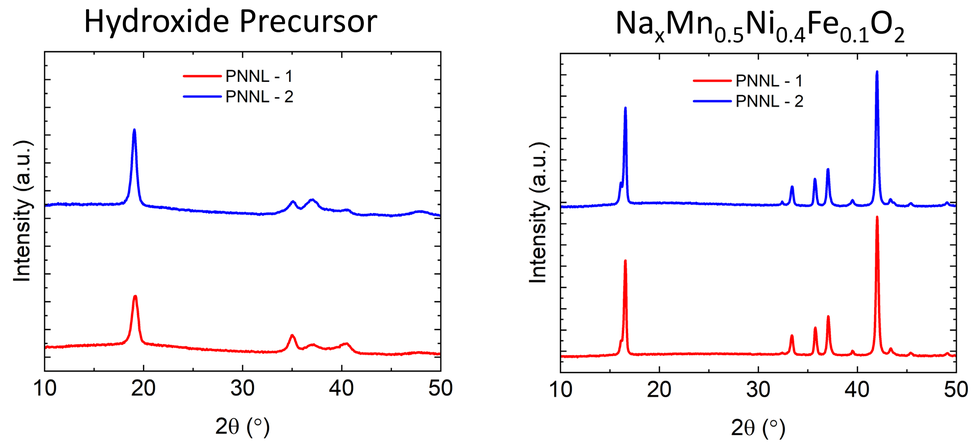
Hydroxide Precursor Morphology





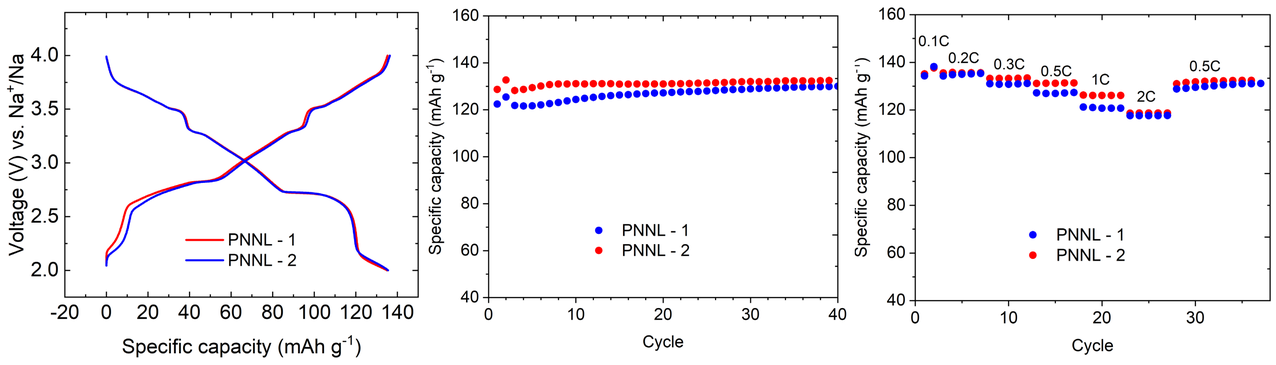
- ❑ Demonstrated controlled
  - ➢ Morphology
  - ➢ Particle size uniformity
  - ➢ Narrow size distribution
  - ➢ Compositional Control

XRD of Precursor and Synthesized Cathode



- ❑ XRD demonstrates correct crystallographic phase for both hydroxide precursor (β-$Ni(OH)_2$) and layered oxide cathodes (O3/P2).

Electrochemical Data of Synthesized Cathode



- ❑ Electrochemical testing demonstrates excellent cycling stability and rate performance

Alignment

This project is accelerating the development and testing of a new energy storage technology that is more cost-effective, safe, and durable, which is crucial to meeting the Administration's goal of providing reliable, affordable, secure, and resilient energy.

Acknowledgement

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