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Sodium Batteries Session Overview

DOE Office of Electricity Energy Storage Program Peer Review

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Sandia National Laboratories

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U.S. DEPARTMENT of ENERGY | NNSA National Nuclear Security Administration

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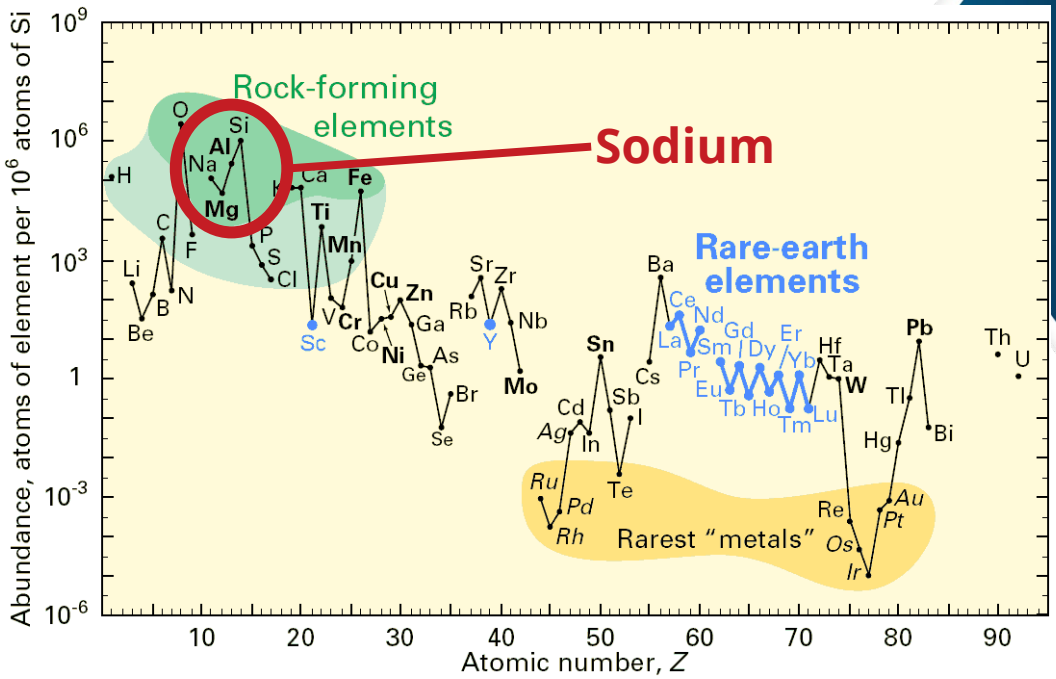
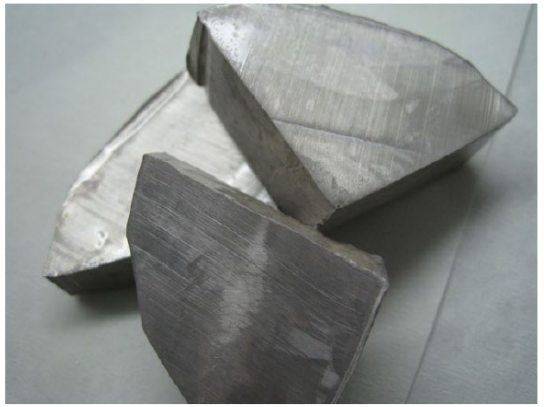
Why Sodium?

- Minimizes use of critical minerals
  - Li, Ni, Co, graphite
- Abundant and can be sourced in the US
  - 6th most abundant element in earth's crust
  - 1000× more abundant than Li
  - 5× the annual production of Al
  - $NaCO_3$ – "washing soda," in everyone's dishwasher
- Only slight decrease in energy storage characteristics vs. Li
  - ~10% decrease in cell voltage vs. Li (-3.0 → -2.7 V vs. SHE)
  - ~Half the volumetric capacity of Li metal anode, though differences in batteries are largely controlled by overall system design and specific cathode chemistries.

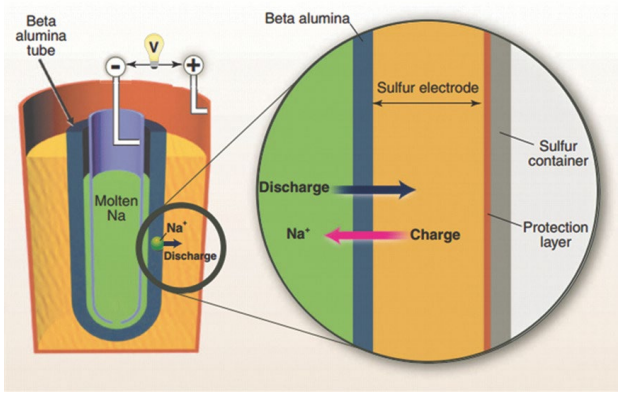




Sodium Metal

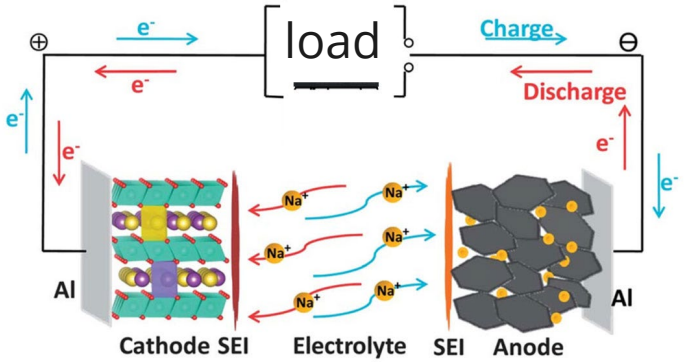
Sodium Battery Types

Molten Sodium



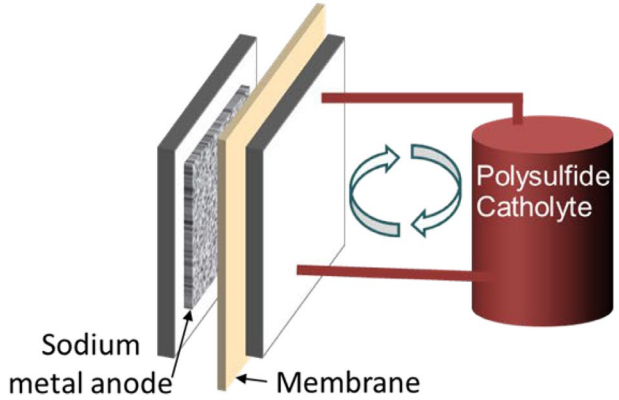
Wang et al. *Adv. Energy Mater.* **7** (2017) 1602829

Sodium-ion



Adapted from Zeng et al. *Front. In Chem.*, **8** (2020) 635

Hybrid Flow Batteries



Adapted from Lehmann et al. *Membranes,* **13** (2023) 700

NaS Batteries by NGK

NGK-insulators.com

Na-ion Batteries for EVs by CATL

CATL.com

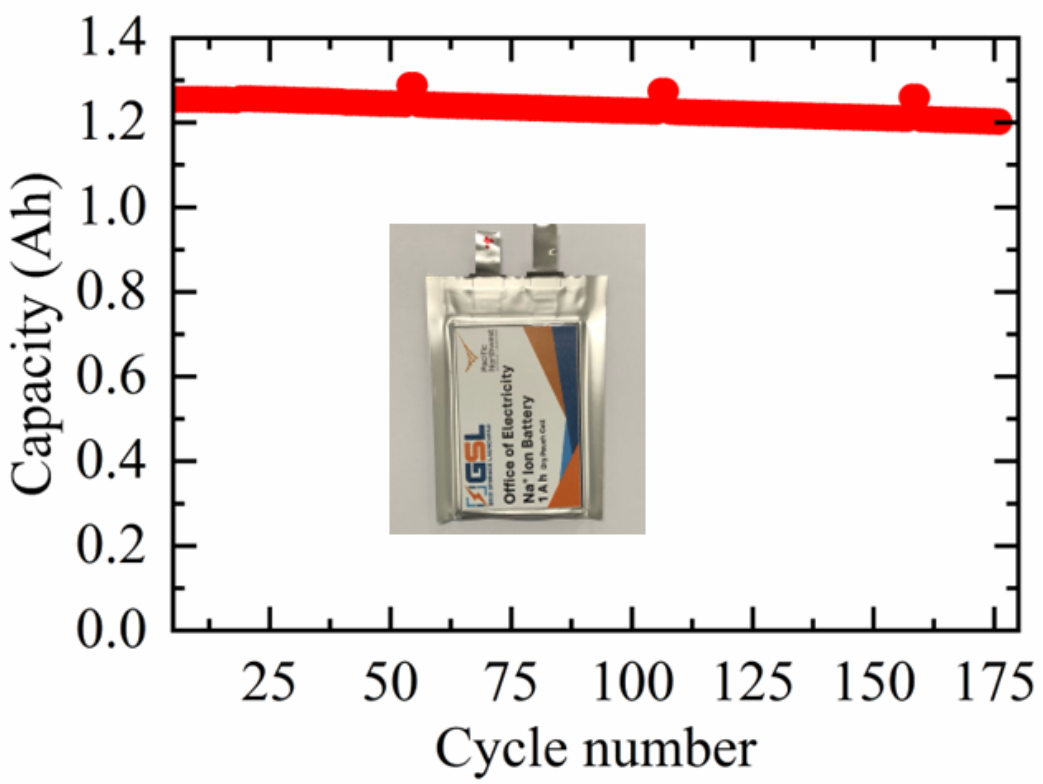
Sodium batteries can come in several forms. All have sodium-based anodes.

Sodium Batteries Session Overview

- **Cutting Edge Fundamental R&D**
  - Guosheng Li (PNNL)
  - Ethan Self (ORNL)
- **Are sodium batteries safe?**
  - Alex Bates (SNL)
- **Can we scale up new sodium battery technologies?**
  - Fredrick Omenya (PNNL)
  - Ruming Tao (ANL)
- **Are sodium batteries economically viable?**
  - Adrian Yao (Stanford)

Sodium Ion Battery Development

Presented by Fredrick Omenya

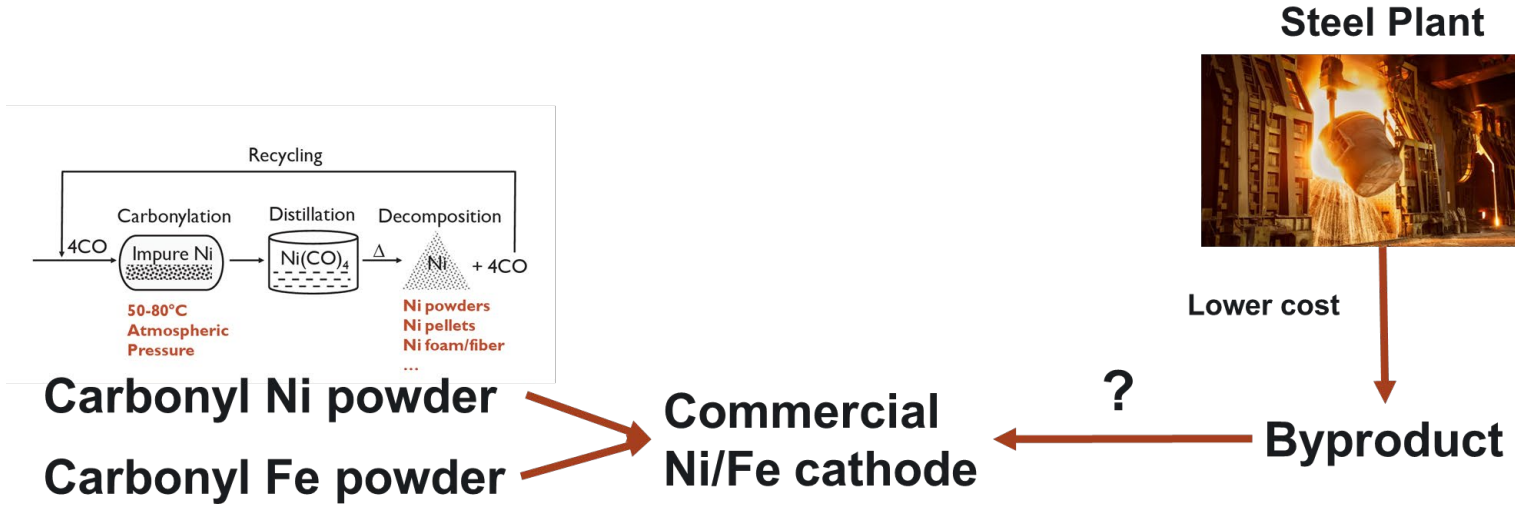


High areal loading (≥ 3 mAh/cm²)
>1 Ah Na-ion pouch cells deliver stable cycling performance.

Intermediate Temperature Sodium-Metal Halide Battery Technologies for Grid Energy Storage Applications

Presented by Guosheng Li

Pacific Northwest NATIONAL LABORATORY

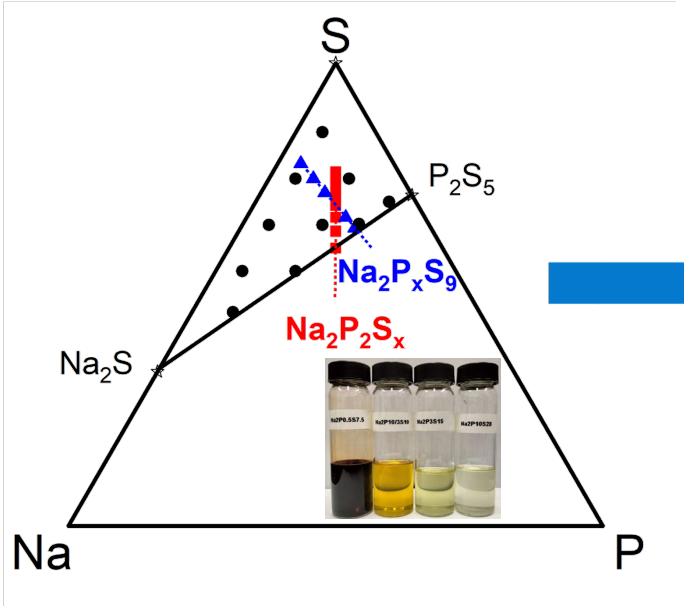


Distinct electrochemical behaviors were identified between mixed powder cathodes and alloy cathodes.

Na-Based Redox Flow Batteries for Grid-Scale Energy Storage

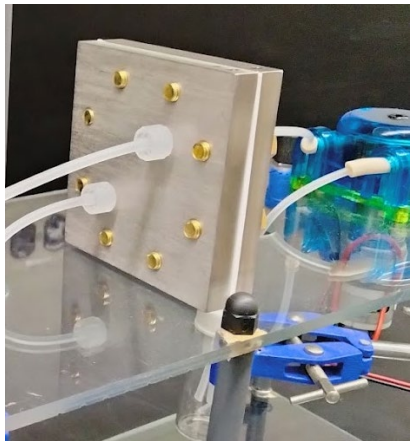
OAK RIDGE National Laboratory

Presented by Ethan Self



Hybrid RFBs

Na Metal Anodes, Na-P-S Catholytes

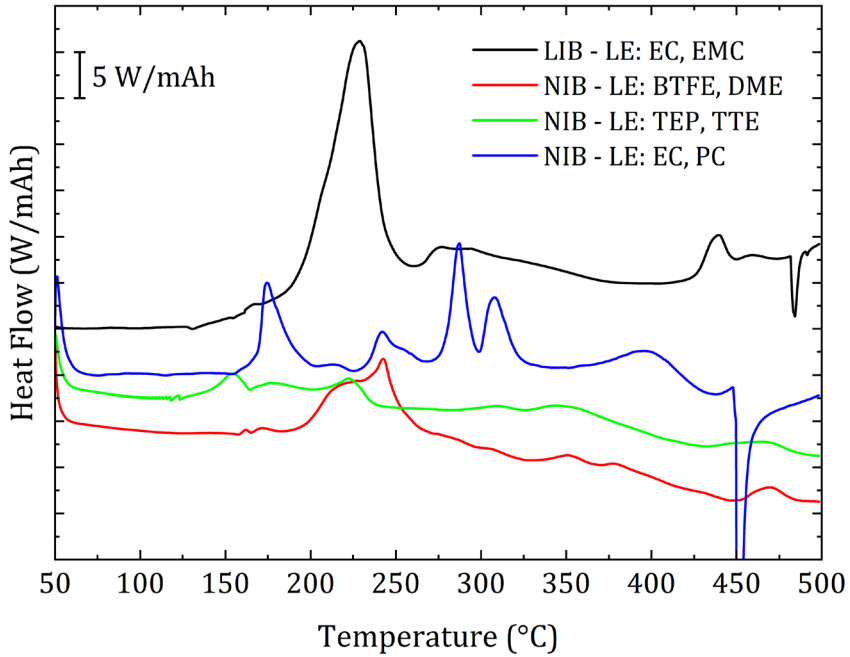


- Solvent-mediated synthesis route developed to produce a new class of Na-P-S catholytes.
- Hybrid RFBs containing Na metal anodes and Na-P-S catholytes show promise to increase energy density and reduce cost compared to traditional flow battery chemistries.

Calorimetric Investigation of Heat Flows in Na-ion Battery Materials

Sandia National Laboratories

Presented by Alex Bates

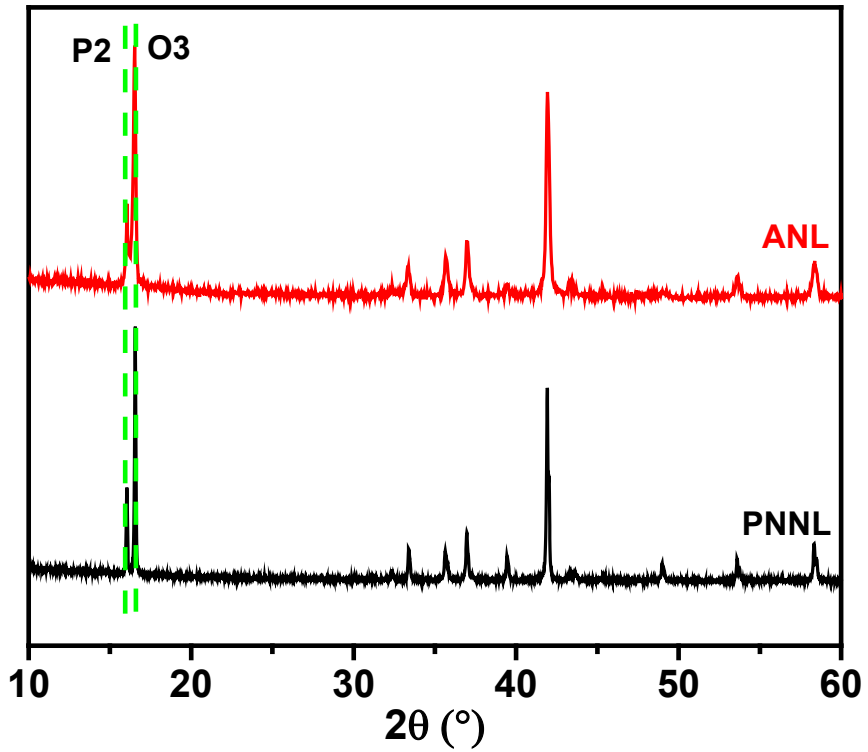


Electrolyte innovation can reduce exothermic heat generation, resulting in improved safety.

Process R&D for Electrochemical Energy Storage Materials Manufacturing

Argonne NATIONAL LABORATORY

Presented by Ruming Tao



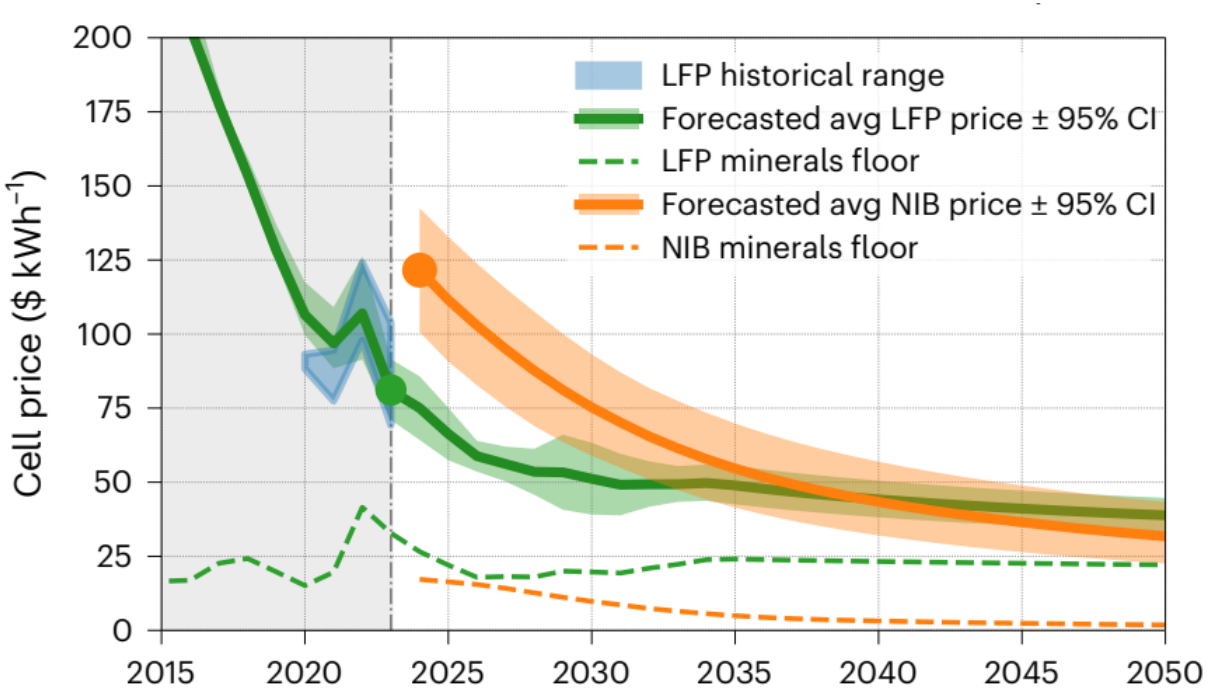
We have successfully conducted upscaling syntheses of the desirable sodium-ion battery cathode material at kilogram level for the grid-scale energy storage pouch cell evaluation at PNNL.

- matched P2/O3 phase ratio
- good stoichiometry
- favorable morphology

Understanding Na-ion's Roadmaps to Competitiveness

Stanford

Presented by Adrian Yao



Yao, Benson, Chueh. *Nature Energy* **10** (2025) 404-416.

Can Na-ion batteries be economically competitive with Li-ion batteries?

Sodium Battery Posters

Poster Title	Presenter	Institution
Low-cost and Long-life Cathodes for Sodium-ion Batteries	Feng Lin	Virginia Tech
Development of Electrolyte for Long Cycling Na-ion Batteries	Donghai Wang	Southern Methodist University
Advanced electrolytes for Na-ion batteries	Chunsheng Wang	University of Maryland
Physics-Informed Machine-Learning Exploration of Na Storage Mechanism in Hard Carbon	Liwen Wang	Lawrence Livermore National Laboratory
High-voltage Electrolyte Design for Sodium-ion Batteries	Dejian Dong	University of Maryland
Intermediate Temperature Sodium-Metal Halide Battery Technologies for Grid Energy Storage Applications	Guosheng Li	Pacific Northwest National Laboratory
Materials innovation and cell development for room temperature Na-S batteries	Xueli (Sherry) Zheng	SLAC
Sodium-Ion Battery Cathodes: Unveiling Synergy, Heterogeneity, and Charge Compensation	Ahamed Irshad Maniyanganam	SLAC
Designing 3D Interfaces and Enhancing Sodium Wettability for Next-Generation Molten Sodium Batteries	Isaac Dyer	Sandia National Laboratories
Glassy Phase Electrical Presence in NaSICON Solid Electrolyte	Ethan Lauricella	University of Kentucky
Low Temperature Sodium Batteries	Leo Small	Sandia National Laboratories
(SAGES) Sodium-ion Alliance for Grid Energy Storage	Xiaolin Li	Pacific Northwest National Laboratory
Realistic Demonstration of Sodium-Ion Pouch Cells for Secure Energy Storage	Marcos Lucero	Pacific Northwest National Laboratory

Acknowledgements

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