Synthesis and Stability of NaSICON for Sodium-Based Batteries

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Why NaSICON?

(Sodium (Na) Super Ionic Conductor)

\[ \text{Na}_{1+x} \text{Zr}_2 \text{P}_3 \text{Si}_3 \text{O}_{12} \]

NaSICON is a high conductivity (up to \(10^{-2}\) S/cm at room °C) solid state electrolyte that is stable against molten sodium and which we are using in development of a family of sodium-based battery technologies.

Select batteries under development
1. Sodium-air
2. Sodium-ion
3. Low temperature sodium-sulfur
4. Sodium-bromine: Na + 1/2 Br₂ ↔ Na⁺ + Br⁻
   3.79 V 987 Wh/kg
5. Sodium-iodine: Na + 1/2 I₂ ↔ Na⁺ + I⁻
   3.25 V 581 Wh/kg

Programmatic Goals and Objectives

• Reduce the cost of energy to < 100 $/kWh
• Develop a suite of sodium-based battery solutions to fill the multiple application needs for stationary storage
• Facilitate short development timeframe

Fully realizing sodium battery potential will require stable, high conductivity NaSICON.

The Chemistry of NaSICON – Toward understanding and optimizing behavior

• NaSICON is a multi-component material having complex chemistry.
• High temperature synthetic routes often produce secondary “contaminant” phases.
• These secondary phases can and do dramatically affect performance and stability.

ZrO₂ Phase Leads to Reduced Conductivity

Scanning electron micrograph of monoclinic \(\text{ZrO}_2\) in NaSICON produced at 1300°C sintering temperature.

Glassy Phases Reduce Stability

Glassy phases, particularly sodium phosphates, decrease stability in alkaline electrolytes.

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