Sodium Intercalation Battery for Stationary Storage

Energy Storage Systems Program (ESS)
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Large-scale stationary energy storage for integration with renewables and for off-peak energy capture is a new application requiring new rechargeable batteries.

- New combination of requirements
  - Long cycle life under deep cycling use profile
  - High cycling efficiency
  - Moderate rate capability
  - Very low cost
  - **No** requirement for particularly high specific energy or energy density

- TIAX is developing a novel Na-ion battery
  - Leverages teachings of Li-ion technology
  - Targets novel low-cost chemistry and cell design

- TIAX has an ongoing Phase I SBIR program
  - contract # DE-SC0006457
TIAX is integrating elements of other technologies for this energy storage application.

• Screen materials vs. Na metal counter-electrode in Na\(^+\) salt-based organic electrolyte
  – Evaluate known Na-ion active materials
  – Evaluate Na analogues of Li-ion active materials
  – Pair anode and cathode materials for combining in Na-ion cells.
• Formulate Na\(^+\) electrolyte for enhanced Na-ion performance.
• Formulate electrodes for enhanced performance in Na\(^+\) electrolyte.
• Demonstrate baseline cell chemistry.
• Develop scaled-up cell designs and rough cost estimates.
• TIAX has an ongoing Phase I SBIR program
  – contract # DE-SC0007475.
Experimental results

Initial anode and cathode materials have been cycled vs. Na metal in organic Na\(^+\) electrolyte.

<table>
<thead>
<tr>
<th>material</th>
<th>average potential V vs. Na</th>
<th>specific capacity mAh/g</th>
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</thead>
<tbody>
<tr>
<td><strong>cathodes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na(_{0.44})MnO(_2)</td>
<td>3.2</td>
<td>65</td>
</tr>
<tr>
<td>NaNiO(_2)</td>
<td>3.1</td>
<td>30</td>
</tr>
<tr>
<td>delith LiMn(_2)O(_4)</td>
<td>3.4</td>
<td>70</td>
</tr>
<tr>
<td><strong>anodes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na(_2)Ti(_3)O(_7)</td>
<td>0.32</td>
<td>90</td>
</tr>
<tr>
<td>V(_2)O(_5)</td>
<td>1.6</td>
<td>140</td>
</tr>
</tbody>
</table>
Cathode materials investigated to date cycle at slightly lower potentials than their lithium analogs ($E_{\text{Na/Na}^+} = 0.25\text{V vs. } E_{\text{Li/Li}^+}$).

Electrolyte: 1M NaPF$_6$ in 1/1 PC/DMC
Possible anode choices span a broad range of cycling potentials.

- V2O5
- Na2Ti3O7

Electrolyte: 1M NaPF$_6$ in 1/1 PC/DMC
Our Phase I SBIR program is now entering into tests of full cell chemistries.

• Candidate active materials screened
  – Additional candidates are still on test.

• Electrolyte formulation experiments are underway.

• Na-ion cell experiments are beginning.