Aluminium Ion Batteries

A VICTORIA UNIVERSITY OF WELLINGTON SCIENCE TEACHING RESOURCE

WHO?

Dr Thomas Nann, an electrochemist at Victoria University of Wellington.

WHAT’S HE DOING?

Developing a new type of battery based on aluminium.

WHY DO WE NEED MORE BATTERIES?

As we make the transition to using more renewable energy sources, a number of challenges need to be overcome. Many of the renewable energy generation methods are not consistent, such as wind or solar, so we need a reliable way to store, and later access, energy when there is an excess.

- What are some ways we could store energy for use at a later date?

Batteries are one of the most obvious forms of energy storage. At the moment, the most widely used rechargeable batteries are lithium-ion batteries (LIB).

WHY ALUMINIUM?

Why Aluminium?

The table below compares different properties of certain elements. Specific capacity refers to the amount of energy that can be stored per unit of mass or per unit of volume.

Answer the following questions:

- Why is lithium not a sustainable element to use for future batteries?
- What are some other issues we know about with lithium-ion batteries?
- Why might have researchers focussed on using aluminium rather than the other elements?
- What might be a drawback of aluminium?

<table>
<thead>
<tr>
<th></th>
<th>Li</th>
<th>Na</th>
<th>Mg</th>
<th>Al</th>
<th>K</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valence</td>
<td>+</td>
<td>+</td>
<td>2+</td>
<td>3+</td>
<td>+</td>
<td>2+</td>
</tr>
<tr>
<td>Atomic weight</td>
<td>6.94</td>
<td>22.99</td>
<td>24.31</td>
<td>26.98</td>
<td>39.10</td>
<td>40.08</td>
</tr>
<tr>
<td>Specific Capacity [A h kg⁻¹]</td>
<td>3862</td>
<td>1166</td>
<td>2205</td>
<td>2980</td>
<td>685</td>
<td>1340</td>
</tr>
<tr>
<td>Specific Capacity [A h⁻¹ l]</td>
<td>2062</td>
<td>1128</td>
<td>3832</td>
<td>8046</td>
<td>591</td>
<td>2060</td>
</tr>
<tr>
<td>Standard Potential [V]</td>
<td>−3.04</td>
<td>−2.71</td>
<td>−2.36</td>
<td>−1.68</td>
<td>−2.93</td>
<td>−2.87</td>
</tr>
<tr>
<td>Abundance [ppm]</td>
<td>18</td>
<td>22700</td>
<td>23000</td>
<td>82000</td>
<td>18400</td>
<td>41000</td>
</tr>
</tbody>
</table>
While aluminium has the advantage of being the third most abundant element on the planet, as well as having a relatively high energy storage capacity, wide scale use of batteries using aluminium as the anode has been limited because historically charge has been transferred between the anode and cathode through an aqueous electrolyte solution.

What do you think that limitation was?

In an aqueous solution, aluminium forms a protective oxide layer that slows down oxidation. This drastically reduces the efficiency of the battery as well as producing hydrogen gas. To avoid this, most researchers use an electrolyte solution made from an ionic liquid containing aluminium chloride (AlCl₃).

Choosing Cathodes

To be a suitable 2D layered cathode, the material needs:

- Pores big enough to allow the electrolyte to move easily.
- Unreactive with the intercalated ions.
- Relatively abundant or easy to produce.

Graphite is a very promising material for aluminium battery cathodes.

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