Blog

What's Inside an Aqueous Hybrid Ion Battery?

by Professor Jay Whitacre

August 10, 2016 at 3:30 PM

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The Aqueous Hybrid Ion (AHI) battery was developed by Carnegie Mellon Professor Jay Whitacre in 2008. Utilizing a water-based electrolyte and multiple functional active ions, AHI batteries address the needs of the energy storage customers and deliver a system that is safe, reliable, and affordable.

What's in the AHI battery?

AHI batteries use materials that, while relatively common and inexpensive, are unique to this battery chemistry.

Aqueous Electrolyte: A battery's electrolyte is the substance through which the active ions flow, from one electrode to the other. The AHI battery's **water-based electrolyte** makes it truly unique, as this is unused in nearly all other battery chemistries.

Multiple Functional Ions: When batteries are discharged, electrons flow from the anode to the cathode through the load, while the ions flow from cathode to anode through the electrolyte inside the battery. The opposite occurs during charging. In the case of AHI batteries, **sodium, lithium, and hydrogen ions all work together** inside the battery to store and release electrical energy.

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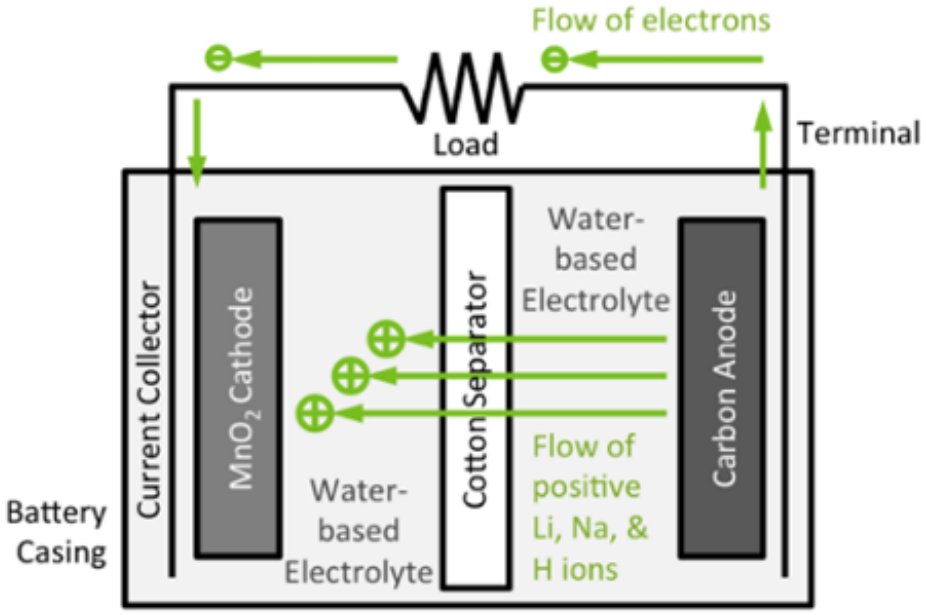

Simple illustration of an AHI battery during discharge. Dimensions not to scale.

Activated Carbon Anode: Carbon, one of the most abundant materials on the planet, makes up the battery's anode, or negative electrode. **Activated carbon is simply carbon powder** with a **high surface area.** This is important because when the battery is in use, a **capacitive interaction** takes place on the surface of the carbon. That means that as the battery is charged, electrons build up inside the carbon, and the surface becomes negatively charged. The active ions, which are positively charged and attracted to the carbon, fix themselves to the surface.

Manganese Oxide Cathode: Found in some Lithium Ion batteries as well as common alkaline batteries, manganese oxide (MnO2) makes up the cathode, or positive electrode. At the molecular level, MnO2 looks like a repeating three-dimensional lattice, with alternating manganese and oxygen atoms. When the battery is discharged, sodium ions flow into the MnO2, and situate themselves between the manganese and oxygen atoms. This means that there is an **"intercalation" reaction** taking place, rather than an electrode surface reaction, which is typically more corrosive and results in loss of capacity over time.

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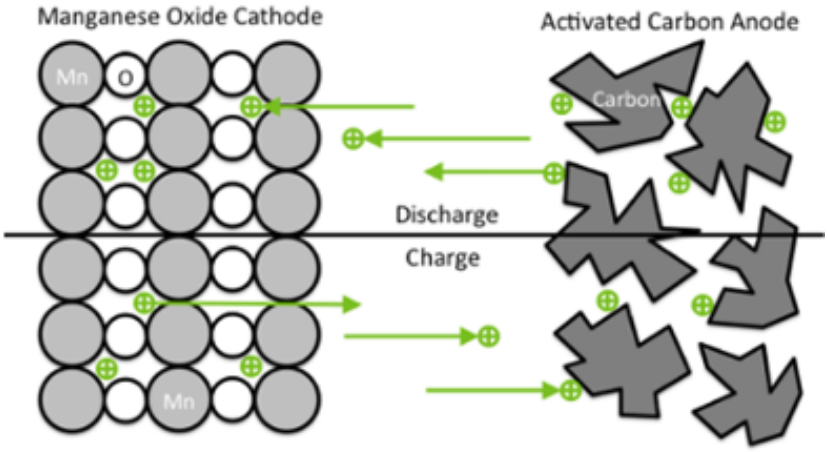

Simple representation of the cathode and electrode interactions during charge and discharge.

Cotton Separator: A simple **synthetic cotton separator** is used to keep the electrodes from directly contacting each other. When soaked with electrolyte, this separator allows the sodium ions to flow between the anode and the cathode, while blocking electrons and preventing a short circuit.

Stainless Steel Current Collectors: The current collectors provide a path for the electrons to flow out of the electrodes.

Want to learn more? Watch Jay Whitacre's recent TED talk **or check out our** technology **or** applications **pages.**

Let us know what battery chemistries you'd like us to dive into next by posting a comment below.

Topics: Energy Storage

Written by

Professor Jay Whitacre
Founder and Chief Technology Officer

Comments

Richard Smith August 14, 2016 at 2:12:12 AM EDT

Do you plan on an automotive battery in the future ?

Reply to *Richard Smith*

Claire Juozitis August 15, 2016 at 11:51:51 AM EDT

Hi Richard,
Our batteries are designed for stationary applications, and that's where we plan to continue our focus. They are ideal for long-duration, deep-cycling applications like solar microgrids. Meanwhile, automotive applications require short-duration, high-power batteries.

Reply to *Claire Juozitis*

Steve Bruniges August 15, 2016 at 5:36:13 PM EDT

What are the characteristics of an aquion battery at the end of its useful life?

Reply to *Steve Bruniges*

> **Claire Juozitis** August 16, 2016 at 9:16:58 AM EDT
>
> Hi Steve,
> Aquion Energy batteries are the only batteries in the world that are Cradle to Cradle certified, meaning that they are not harmful to humans or the environment from the beginning of their useful life to their disposal. Aquion batteries can be recycled and/or thrown away with your normal waste stream!
>
> Reply to *Claire Juozitis*

Mavelikalam Narayanan January 26, 2017 at 9:09:50 PM EST

We are designing an elecric propelled house boat with 48 volt motors.Can we use your batteries for this application?The motors need about 30 hp

Reply to *Mavelikalam Narayanan*

> **Claire Juozitis** January 27, 2017 at 12:32:30 PM EST
>
> Hi Mavelikalam,
> Thanks for your question! Our batteries are designed for stationary, long-duration applications. Unfortunately, they

are not suitable to powers vehicles or boats.

Reply to *Claire Juozitis*

Federico Cattaneo February 1, 2017 at 4:13:28 AM EST

Because of practical inevitable slight differences in each cell composing the battery pack what happens during the end stage of recharge when cells in series need to equalize their state of charge?
With flooded lead-acid or nickel-iron we have electrolysis and consequent water consumption easily fixed by adding distilled water, we can restore the water lost in Aquion battery as well?
Anode and cathode are of different materials so what happens during a deep discharge if a weak cell get polarity reversed?
Lead-acid have lead on both plates so they tolerate it assuming they receive a full charge soon after to prevent lead-sulphate crystallization.
Nickel-iron does not tolerate it because of different plates materials wich wil cause iron contamination into the positive, they can be discharged to 0 and left there as long as you like but can't be reversed, so i wonder if Aquion battery is the same.

Reply to *Federico Cattaneo*

Claire Juozitis February 1, 2017 at 2:02:14 PM EST

Hi Federico,
Thanks for your comment! To answer your questions:
-The AHI chemistry does not require any active management or balancing of the cells. There is natural balancing that happens inside our battery stack within the operating voltage range which means we do not require any special profiles or conditions to balance the cells.

-No, the AHI battery is not capable of being refilled with water. When used within the voltage and temperature windows specified for the product, there is no need to add water.
-The AHI chemistry can be discharged down to 0V and left to sit without any impact on life. Both the anode and cathode are tolerant of sitting at 0V without any contamination or either electrode.

Reply to *Claire Juozitis*

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