Science Writing Competition 2015 – Winning entry

Below is the winning entry in the '20 and under' category for the 2015 international Science Writing Competition organised by the University of the West of England's Science Communication Unit and BBC Focus magazine.

Winner: 20 and under

Charging Ahead with the Future
Emily Clements, aged 14

Sick of waiting 60 minutes for your lithium-ion mobile phone to charge? Researchers from Stanford University think they've found the solution; they have created a battery that it is claimed can charge your phone in just 60 seconds - it's an aluminium-ion based battery.

The team of researchers led by chemistry professor Hongjie Dai has developed an aluminium-ion battery that offers many significant advantages over the conventional lithium-ion batteries currently used in most electronic devices and today's electric vehicles. Let's take a look at what makes the Stanford aluminium-ion battery such an important breakthrough.

The Aluminium-ion battery is flexible. The Stanford team placed the aluminium anode and graphite cathode, along with an ionic liquid electrolyte, inside a flexible polymer-coated pouch. Not only is it supple, you can find evidence of the team drilling a hole through the pouch to demonstrate that it doesn't catch on fire, and even more impressive is that the power lingers for a few seconds afterwards. Not only is it non-flammable and flexible, it's also relatively inexpensive and more environmentally friendly than alkaline models such as AA and AAA.

"Millions of consumers use 1.5-volt AA and AAA batteries. Our rechargeable aluminium battery generates about two volts of electricity. That's higher than anyone has achieved with aluminium," said Professor Hongjie Dai.
"We accidentally discovered that a simple solution is to use graphite, which is basically carbon. In our study, we identified a few types of graphite material that give us very good performance," Dai explained.
"The electrolyte is basically a salt that's liquid at room temperature, so it's very safe," said Stanford graduate student Ming Gong.

However, the battery only generates around two volts of electricity, (which is around half that of a typical lithium-ion battery.) Nevertheless, the researchers are confident they can improve on this. "Improving the cathode material could eventually increase the voltage and energy density," says Dai.

So how are aluminium-ion batteries better than lithium-ion used in the bulk of today's technology? Despite its overall advantages, lithium-ion has its drawbacks. It's fragile and requires a protection circuit to maintain safe operation. Built into each pack, the protection circuit limits the peak voltage of each cell during charge and prevents the cell voltage from dropping too low on discharge.

Lithium is toxic and must be disposed of with care. Billions of small lithium batteries power our assortment of electronic gadgets that we can't live without. Replacing them with aluminium batteries would rid the environment of hazards from discarded lithium batteries.

In addition, the cell temperature is monitored to prevent temperature extremes. The maximum charge and discharge current on most packs is limited to between 1C and 2C. With these precautions in place, the possibility of metallic lithium plating occurring due to overcharge is virtually eliminated.

Since the aluminium-ion battery weighs more than lithium-ion ones and since at the moment it doesn't have enough power to keep your phone running, it's improbable for it to be in any device for the time being. Perhaps, in the near future science will have caught up with this idea.

However, perhaps the aluminium-ion battery may be deployed on the grid one day. It might be the perfect fit for the battery that is providing balancing and reserve power to the electric grid in order to maintain the balance between total electricity supply and total electric demand. This application requires high-power batteries with the capability to charge and discharge many times without failing.

In 1859, the French physicist Gaston Planté invented the first rechargeable battery. It was based on lead acid, a system that is still used today. The very first attempt to develop the Li-Ion Battery Pack began in 1912 by an engineer named G.N. Lewis but it wasn't until the 70s that the first non-rechargeable lithium battery packs became commercially accessible. In the past hundred years we have transformed everything. Technology is advancing faster than ever. In the last 50 years we did what many thought impossible hundreds of years ago.

Everything has a battery these days – but today's battery is a toxic hazard. Maybe the aluminium-ion battery will be the eco-friendly, cheap to produce, high performance future of batteries.