Global industry drives the dry cell

BY **DAVE SAMMUT**

The humble battery is an inspiring thing, embodying the grand scale of human endeavour.

Their technology is so elegant, so simple, and it would be hard to find a household anywhere in the country that didn't have a few batteries somewhere – in a drawer, or (if you want them to last longer) in the fridge. These compact cells are little charges of chemical energy just waiting to burst forth.

But how does a battery work? In simple terms, some materials 'want' electrons more than others. If you touch zinc to iron, then the zinc will give up its electrons to the iron when some other factor comes calling. This is why galvanising steel with a coating of zinc protects it from corrosion. As the oxygen in the environment tries to take electrons away from the iron (causing it to rust), the iron in turn takes those electrons from the zinc. Bit by bit, the zinc gets eaten away; but as long as the zinc lasts, the steel shouldn't rust.

The same is true for boats. Most steel vessels have a magnesium, zinc or aluminium 'sacrificial anode' that

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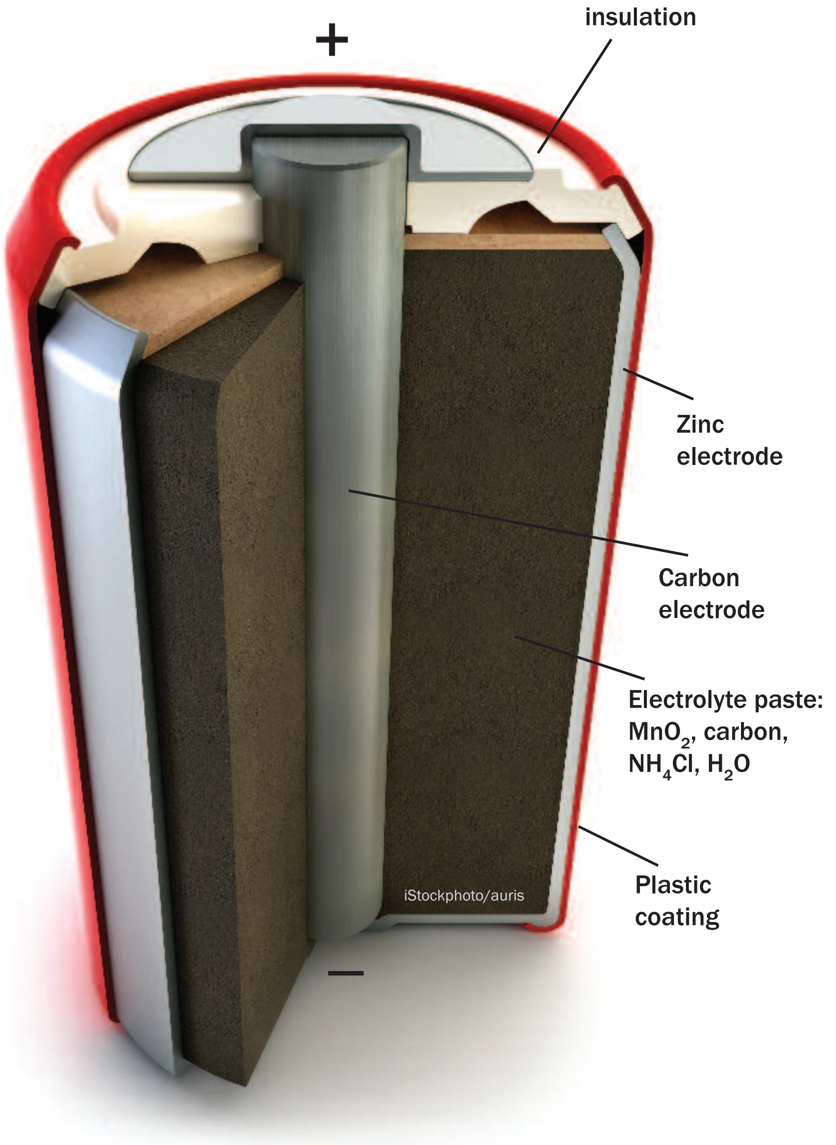
helps protect them from corrosion. Sodium would do the job even better than these metals, except it reacts so violently with water it would explode, and ships with large holes just aren't that useful.

So, if the two metals are touching, the electrons flow from one to the other. If you separate them and put a conductor in between, then the flow of electrons is electricity. That's all a battery is – an incomplete circuit, with two electrodes and a conductor in between, and a driving force between two materials that have different attitudes to electrons.

Batteries are based on simple, straightforward principles, yet those principles have taken many generations of clever men and women working together to discover, share and build knowledge. The household 'dry cell' battery represents the perfection of a leap forward in science that started in the second half of the 18th century with such pioneers of electricity as Benjamin Franklin, Luigi Galvani and Alessandro Volta, yet it uses the same principles as were developed all those years ago.

Allesandro Volta's original 'voltaic pile' used discs of zinc and copper metal separated by brine-soaked cardboard. It worked, but it wasn't as efficient as it could be. The alkaline battery, a modern dry cell battery, is actually pretty similar. It still uses zinc as one of its electrodes, which wraps around the outside of the battery, just



Cutaway diagram of a type of dry cell battery. Dry cell batteries are named for their electrolyte (conducting medium), which is a paste rather than a solution. Alkaline, lithium, nickel–metal hydride and silver oxide ('button') cells are all types of dry cell.

under the plastic coating. The big difference from the original design is that the 'zinc–carbon dry cell' uses solid manganese dioxide and graphite as the other electrode instead of Volta's copper, and a paste of ammonium chloride as the internal conductor instead of the soggy cardboard. There are no messy liquids, which is why it is called 'dry'.

In simple terms, when a circuit is made from the negative to the positive terminal of your battery, the manganese dioxide 'sucks' the electrons around that circuit from the zinc anode to the carbon cathode with 1.5 volts of pulling power.

But as a chemist, here's the thing that truly inspires me. This elegant little battery is the product of a huge amount of science, and a huge global industry goes into its manufacture. Every day, tens of thousands of people work to produce the metals that are (quite literally) the framework of modern society.

Just about every component of a battery – the metallic zinc and copper, the manganese dioxide, even the plastic coating on the outside – is a product from mining and minerals/petroleum processing. Australia is the world's largest producer of zinc, and the equal second largest producer of manganese.

Although the chemistry of these two metals differs markedly, their production uses the same basic principles. You might remember a chemistry experiment from high school, in which two electrodes are put into a beaker of bright blue copper sulfate solution and wires are connected to a transformer. You would have 'plated' a thin layer of copper onto something metal, such as a coin.

Producing zinc or manganese dioxide is basically the same. In both cases, the ore is mined from the ground as a mixture of the metal and oxygen or sulfur (ZnS, ZnO or MnO_2). These ores are impure, so the target minerals are separated from all of the other rocks and minerals that are not wanted (called 'gangue'). Then, concentrated acid solutions dissolve the minerals into solution in huge stirred tanks, each tank about the size of a backyard swimming pool. After filtering off the residual solids in filters the size of buses, we end up with concentrated, highly coloured liquids containing the dissolved metals dissolved. Think of it as cola – concentrated, acidic, and really not good too drink in excessive quantities.

In industry, this is jokingly called 'bucket chemistry'. At this huge scale we add a bucket of this, a bucket of that to get the desired product – sometimes quite literally. In my first job as a chemist, I spent many an hour hauling buckets of soupy mud from one place to another in an experimental plant for minerals processing.

Of course, the detail can get a bit more complicated than that, particularly when we get to the part about purifying the electrolytes. But generally, chemistry is on our side, and there are some truly clever tricks to efficiently separate one dissolved metal from another.

Then comes the modern part of the technology. By using electricity to force the electrons to flow in the desired direction, we can either push them into the dissolved zinc to make it plate out (just like you did at school) or forcibly strip extra electrons out of the dissolved manganese so that it precipitates in just the right form (called electrolytic manganese dioxide). For zinc, that leaves it ready to lose electrons again, and for manganese it makes it particularly hungry to get its electrons back. And that stored imbalance between the two is what makes a battery work so well.

We face many challenges, not least the overwhelming weight of the human population's dependence on limited resources. Yet how grand are those quintessential human characteristics that both create and solve these problems: ingenuity, curiosity, cooperation.

When a bad storm hits, or a fuse blows, or we just forget to pay the electricity bill, the lights go out and we reach for a torch. And that humble battery is standing by, ever ready, awaiting the day that we need it.

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