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Beating the battery barrier

Electric cars need batteries that store plenty of energy, deliver it quickly and then recharge in the time it takes to gulp a cup of coffee. BASF researchers are developing the solution

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JUST a few years ago, electric cars were an option only for technology enthusiasts or hardcore environmentalists. Slow and expensive, they took several hours to recharge and their dismal range could leave you stranded before you even cleared the suburbs.

By 2020, that picture will look very different. You will be able to recharge your electric sports car in the time it takes to drink a coffee, then drive 500 kilometres before needing to top up.

The electric car revolution is upon us, spurred on by environmental regulation, government incentives and rapid innovation. The International Energy Agency predicts the number of electric vehicles on the road worldwide will increase from 2 million today to 20 million by 2020, and to 70 million by 2025. The Chinese government is set on boot-strapping its car industry into the electric age with tax breaks, research subsidies and a ruling that by 2020, 12 per cent of all vehicles sold in the country must be electric. And the UK, France, Norway, India and several other countries intend to go one better by phasing out petrol and diesel engines entirely in the coming decades.

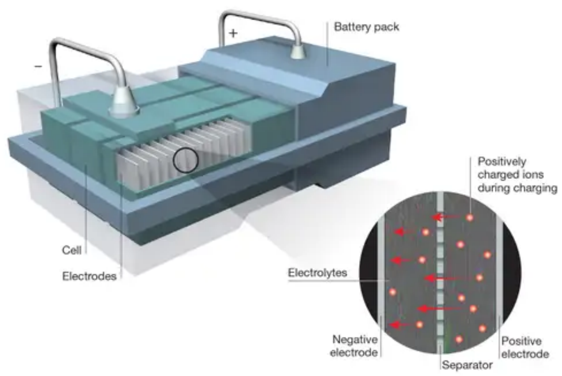
None of this will be possible without a parallel revolution in the way we store and transport energy. An electric car's performance is driven largely by the quality of its battery. Developing powerful, long-lasting, safe batteries that can store lots of energy is crucial for this vision.

One company at the forefront of all this is BASF. The German chemicals giant supplies most leading battery manufacturers with one of their most important components: the material that makes up the cathode electrode in a lithium-ion battery. "The cathode material determines the key properties of the battery, such as its energy content, safety and life span," says Markus Hoelzle, who oversees BASF's battery materials product development. "There is a huge need for improvement in this area because of the demand for low-cost, safe, fast-charging batteries with an extended driving range."

Lithium-ion batteries generate current through the movement of ions and electrons. When the battery discharges, the lithium ions move through an electrolyte from one electrode (the anode) to another (the cathode).

The lithium ions collecting on the cathode add positive charge, which attracts negatively charged electrons. As the electrons move through an external circuit to the ions, this creates the current that powers the car. During charging, this process occurs in reverse.

Tomorrow's high-performace lithium-ion battery



The reason the cathode material plays such a critical role is that it is largely responsible for enabling the flow of ions.

In the first lithium-ion batteries, introduced by Sony in 1991, the cathode electrodes were made of lithium cobalt oxide, which has a high energy density. But cobalt is expensive. If lithium cobalt oxide were used in a battery giving a 400-kilometre driving range, the cobalt alone would cost more than $5000.

To make batteries more affordable, BASF replaces some of the cobalt with nickel, which is a fifth of the price . In some respects, nickel makes an even better cathode material because it has twice the energy density. But the oxygen in this mix can be released at a relatively low temperature, raising the risk of fire. The solution is to add another metal to stabilise the mix, usually manganese or aluminium, which are electrochemically less active.

BASF's researchers spend a great deal of time studying these combinations and understanding their properties. This job is made more difficult by the varied demands of battery makers. For example, different kinds of electric vehicles prioritise different features.

Fully electric cars require batteries with lots of storage capacity to maximise driving range. This requires a cathode with a high energy density – one that can absorb as many lithium ions as possible in as small a space as possible.

Nickel is great for this, and the more nickel you can pack in, the greater the driving range – but the higher the fire risk. Finding the optimal nickel content for a safe, high-energy battery is one of BASF's major research challenges. "Our aim is to achieve the maximum energy density with a material that is safe," says Hoelzle.

In contrast, for hybrid cars the rate at which the battery delivers energy is more important than storage capacity. That's because hybrids tend to use their batteries in bursts, such as when accelerating away from a stop.

To provide high power, a battery must move large numbers of lithium ions quickly from the anode to the cathode. So BASF's researchers design cathode materials using small particles, which leave gaps for lithium ions to move in and out of quickly. It helps even more if the cathode material is porous: more holes means more space and greater ion flow.

This kind of cutting-edge research should significantly lower the cost of batteries. Lithium-ion car batteries cost around $200 per kilowatt hour of energy.

Jeffrey Lou, who runs BASF's global business unit for battery materials, thinks improved technologies will help bring that down to $90 per kilowatt hour. "But innovation will be key on the material side, on efficient production processes and on the recycling of used batteries," he says.

The impacts will be significant. Affordable electric cars will lead to quieter, cleaner cities but will also change the way we live. For example, you should be able to drive to the supermarket and charge your car while you do your shopping, then pay for your energy and food together. "The technology is already visible on the lab benches," says Hoelzle. "In the near future, we'll be seeing a completely new type of mobility."

Metals supply

As demand for electric vehicles increases, so will the demand for the raw materials to make them. This is a major challenge for BASF, which requires regular supplies of nickel, cobalt, manganese, aluminium and lithium for its battery components.

BASF has recently announced a collaboration with the Russian mining company Norilsk Nickel, to guarantee a stable supply of responsibly-sourced nickel and cobalt.

At the same time, the company is developing ways to reduce the proportion of cobalt needed in battery components called cathodes. The current standard is 20 per cent, alongside 50 per cent nickel, 20 per cent manganese and 10 per cent lithium.

BASF's research and development team has developed new cathode materials that use only 10 per cent cobalt, and is working on reducing that further down to 5 per cent. The company plans to do this by increasing the proportions of nickel and manganese, which are cheaper and more widely available.

But the challenge will be to do all this while maintaining the safety of the battery.

- More at: www.automotive.basf.com/applications

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