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Self-repairing batteries promise longer life and range for electric cars

To achieve better and longer lasting batteries for electric vehicles, EU-funded researchers are developing technology that enables batteries to quickly detect damage and repair themselves.

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Batteries are one of the biggest speed bumps on the road to mass electric vehicle (EV) adoption. But what if they could not only last longer, but also repair themselves? That is the vision driving researchers such as Johannes Ziegler and Liu Sufu, who are working to make this a reality.

EV sales in Europe are surging, up 20% in February compared to the same month in 2024. EVs are essential for electrifying our transport and reducing planet-wrecking carbon emissions, but their journey is not without challenges.

Most EVs rely on lithium-ion batteries, similar to those in our phones, but much larger and more complex. An EV battery contains tens of kilograms of valuable metals – lithium, nickel and copper – and must last for over a decade, matching the expected lifespan of an EV.

To tackle this challenge, a team of researchers has gathered under an EU-funded initiative named PHOENIX, aiming to develop batteries that can heal themselves. Their goal is to extend battery life, make them safer and reduce the need for new battery metals.

“The idea is to increase battery lifetime and reduce its carbon footprint because the same battery can repair itself so that fewer resources are needed overall,” said Ziegler, a materials scientist at the Fraunhofer Institute for Silicate Research ISC in Germany.

In 2023, the EU identified 34 materials as critical, including battery metals such as lithium, nickel, copper and cobalt.

The PHOENIX project is named after the mythical bird that rises from its own ashes – a fitting symbol for the rebirth and renewal the researchers hope to achieve in battery technology.

And the stakes are high. EU legislation requires all new cars and vans sold from 2035 onwards to generate zero emissions. The aim is to significantly cut greenhouse gas emissions from the transport sector.

For that to happen, electric cars will need better batteries.

Sense and trigger

Anyone who owns a smartphone knows the frustration with batteries: after a few years, their lifetime plummets. The same issue plagues EVs, just on a larger scale.

This happens because parts of the battery degrade as it is repeatedly charged and discharged over time.

Scientists from Belgium, Germany, Italy, Spain and Switzerland are collaborating to design sensors that detect changes within a lithium-ion battery as it ages, and trigger the battery's self-healing when needed.

The aim is to double the lifetime of the batteries and, by extension, the life of EVs.

Today, battery management systems (BMS) – the brains of a battery – monitor the voltage and temperature of a battery to ensure it does not overheat and cause safety problems.

"Currently, what is sensed is very limited in general temperature, voltage and current. In addition to providing an estimation of the remaining energy availability, it ensures safety," said Yves Stauffer, an engineer at the Swiss Centre for Electronics and Microtechnology (CSEM), an innovation centre that develops disruptive technologies. Stauffer leads the BMS research.

The PHOENIX team aims to go further by introducing advanced sensors and triggers. Some of them will detect when the battery expands, others will generate a heat map, and some will watch for dangerous gases such as hydrogen or carbon monoxide.

All these sensors will provide an early warning system for battery health.

When the battery's brain decides repair is needed, healing is activated. This could mean squeezing the battery back into shape, for example, or applying targeted heat to trigger self-repair mechanisms inside.

"The idea is that under thermal treatment, some unique chemical bonding will bounce back," said Sufu, a battery chemist at CSEM who also works on PHOENIX.

Another self-healing approach uses magnetic fields to break up dendrites – branching metallic structures that form on battery electrodes during charging and can cause short circuits and failures.

Size matters

PHOENIX researchers also aim to increase the range of EVs and reduce the size of batteries.

"We're trying to develop next-generation batteries with higher energy density," said Sufu. That means an EV would require a smaller battery, which would make it lighter and allow it to drive further on a single charge.

One strategy is to replace graphite, the material used in pencils, with silicon, which sits somewhere between metals and non-metals.

This is not widely adopted in today's commercial batteries, partly because silicon is less stable and its volume can expand up to 300% during charge and discharge, Sufu said. With silicon inside, a battery would have to be able to survive these drastic changes or repair itself.

In March 2025, a new batch of sensor prototypes and triggers was developed and shipped to partners for testing on battery pouch cells – flexible, lightweight and flat lithium-ion batteries.

However, while loading a battery with sensors is great for providing information on its health status, it also adds to the cost. The team is therefore focused on identifying which technologies deliver enough benefit to justify the cost of EVs.

Whichever approach prevails, it will enable future EVs to last longer and drive further, with safer, more compact, and less resource-intensive batteries.

Extending battery life will also reduce the carbon footprint of EVs, offering a win-win for both consumers and the environment.

“It is exciting to prolong the lifetime of batteries and work on EVs,” said Ziegler. “It is all about bringing the parts together.”

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More info

- PHOENIX
- PHOENIX project website
- Sustainable and Smart Mobility Strategy
- EU batteries regulation
- Critical and strategic materials