

# EV BATTERY PROGRESS VOL 3

MARCH 10, 2025

## Creating a self-repairing and environmentally friendly EV battery

by Silje Grytli Tveten, [Norwegian University of Science and Technology](#)



Next-generation electric car batteries set a new standard: a longer lifespan, faster charging and more sustainable materials. Researcher and project manager Nils Peter Wagner is shown in the lab at SINTEF. Credit: Silje Grytli Tveten

Imagine that you are traveling down one of Europe's many superhighways with your new electric car. You're moving along fast, and charging stations are few and far between. The memory of range anxiety kicks in, but then you realize that the car you are driving has a brand-new electric car battery, developed precisely to be able to drive long distances and not have to charge often. And when you do have to stop, charging also takes much less time.

With this in mind, and the certainty that the new batteries are also more environmentally friendly, you relax into your seat and drive on with confidence.

### More power in every 'drop'

The EU is investing in the production of new EV batteries that meet the needs of future electric car users for more sustainable, cheaper and more efficient batteries. The goal is that as many people as possible choose to buy and drive with sustainability in mind.

Nils Peter Wagner is a senior research scientist at SINTEF and is coordinating the work taking place in the EU project IntelLiGent. He says the researchers in the project have experimented with both [advanced materials](#) and components to improve the batteries.

"In many ways, you could say we've created a 'recipe' for future battery technology by choosing some of the best, cheapest and least environmentally harmful raw materials. We have plumbed every last detail of the battery cells," says Wagner.

## Superpowers and secret ingredients

Think of the battery as a sandwich: At the top we find a cathode. The cathode uses the IntelLiGent material LNMO, which stands for lithium-nickel-manganese oxide. The material is cobalt-free and contains less lithium and nickel than materials used in today's batteries.

These are all materials that are defined as critical raw materials. The batteries using the researchers' alternative components thus have a lower environmental footprint.

"The LNMO cathode material provides high average voltage, without fail. It also has [high energy density](#), which means that it can create more energy in a smaller volume, so that the battery has a longer range, says Wagner.

However, one challenge has been that the material has had some "growing pains" that have resulted in a shorter lifespan. The researchers have improved this situation by developing a new generation of LNMO cathodes that provide better performance and capacity for the batteries, according to the researcher.

At the bottom of the battery we find the anode. The new batteries are made of a composite consisting of silicon and graphite. Silicon can absorb many more lithium ions, which provides more energy, while graphite provides strength and stability, so that the battery lasts longer.

Both silicon and graphite are critical raw materials. IntelLiGent's silicon-graphite composite batteries are produced by Vianode in Norway, which can produce materials with both lower emissions and resource consumption.

## Follow-up problem solved

"These energy-efficient, high-capacity anodes play a crucial role in improving battery performance. However, silicon anodes swell significantly during charging and discharging, and this can cause the material to break down. We have solved that problem by exploiting the stability of graphite, so that the batteries have the best possible durability and lifespan," says Wagner.

The research team is also developing a "secret sauce": a special electrolyte that protects the anode and cathode in the batteries. This makes them more stable and lasts longer.

"We recently completed development of the electrolyte and tested it in a first-generation prototype. Now we've put the spotlight on the second generation of prototype cells, which will provide higher energy density and use even larger cells. This will in turn give the batteries even better performance and efficiency," says Wagner.

## **Superglue repairs minor damage along the way**

The project has also worked on the structure of the battery itself—in other words, how the electrodes are constructed and how the battery is assembled, which will increase both the energy density and charging capacity.

"One effect of higher energy density is that the battery can get too hot, so we need to ensure that the structure does not allow heat to build up inside the battery," says the SINTEF researcher.

In order to hold the "sandwich" together, the researchers also use special binders and separators. These parts are not passive helpers, but active components that can repair minor damage along the way. While the binders help to maintain the electrode structure, the separators ensure that the electrodes are kept physically separated, thus preventing short circuits.

"The binders and separators allow the batteries to protect and repair themselves, which in turn helps to extend their lifespan."

## **A virtual test track**

To better understand the behavior of the battery cells, the researchers use advanced analysis methods and modeling. This provides useful answers about how the design can be improved.

Using lightning-fast screening methods and modeling tools, they explore the possibilities, looking for the most environmentally friendly solutions, including testing the batteries in a digital world. By using a [software tool](#) developed at SINTEF, the researchers can test how the batteries behave. In this way, they save time and gain confidence that the technology is working as it should.

## **From lab to market**

The work happening at IntellLiGent occurs in collaboration with important players throughout the value chain, from manufacturers to suppliers and end users. The goal is to arrive at the best possible "[battery recipe](#)."

The project team has a detailed plan for how the technology can be brought to the market. They are now working on getting the production of electrodes up and running on a large scale, and optimizing production and test protocols. They will also produce a demo model to check that the batteries perform and are as safe and durable as they should be.

## Toward a greener future on the road

"We are assessing environmental, economic and social consequences and comparing the new technology with current solutions," Wagner says.

According to the researchers, this EU project paves the way for a greener automotive future, with batteries that are more powerful, more efficient and less harmful to the planet.

"These batteries will enable you to drive your electric car farther without charging and you'll be able to charge it faster. And as an individual, you'll also be contributing to a smaller carbon footprint," says the SINTEF researcher.

Provided by [Norwegian University of Science and Technology](#)

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## Lithium-Sulfur Battery Breakthrough Could Dramatically Improve Electric Vehicles

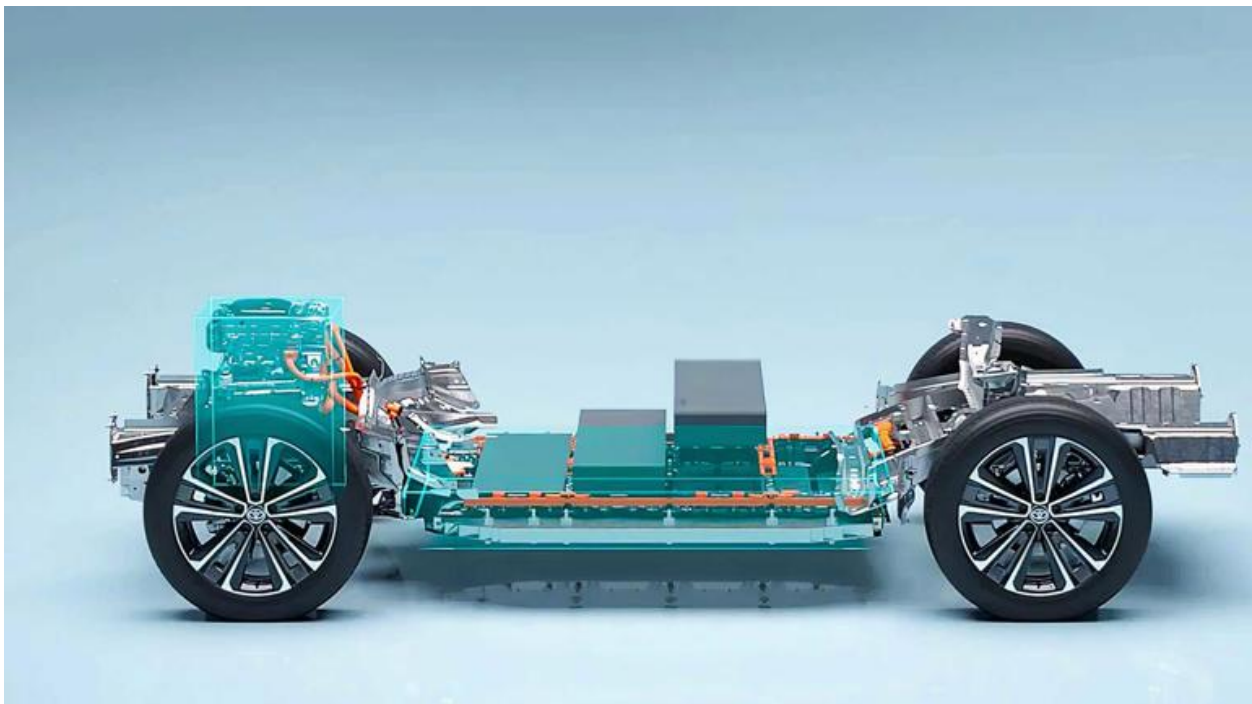
[Electric vehicles](#) have a host of benefits over gasoline- and diesel-powered cars and trucks. EVs provide nearly silent, almost vibration-free driving, they're cheaper to fuel if you charge at home, you get instant off-the-line torque, and electrics require dramatically less maintenance. But the one big problem with EVs is today's battery technology. [These energy-storage systems](#) are bulky, heavy, expensive to manufacture or replace, and they never provide as much range as drivers would ideally like, but folks at Florida International University's Battery Research Lab may have developed a breakthrough technology.

[According to a report from the Miami-based school](#), researchers are working on some next-generation battery designs, chemistries that go beyond lithium-ion, the latest and greatest that's currently available. Bilal El-Zahab, associate professor in the College of Engineering and Computing, along with others, is working on improving the lithium-sulfur chemistry.

Since sulfur is plentiful and holds more energy, this design provides numerous benefits over what's available today. These batteries are less expensive, lighter in weight, and incredibly energy-dense, major upsides that are ideal for electric vehicles. But there's a problem, and it's a huge one. Lithium-sulfur [batteries work amazingly well](#), though they may be rendered completely useless after just 50 or so charges, and that basically renders this technology a non-starter.

During charging and discharging, ions move around inside these batteries. This chemical reaction between the sulfur and lithium generates polysulfides, or “lithium-containing sulfur compounds,” which, in short order, muck up the delicate internal balance, quickly rendering a battery useless. “We started working with these next-generation battery chemistries eight years ago,” said El-Zahab in a story published by FIU News. “The first charging cycle was great. By cycle 20, it was a useless lump of metal,” he added, underscoring the issue at hand.

## The Secret Ingredient: Platinum Nanoparticles



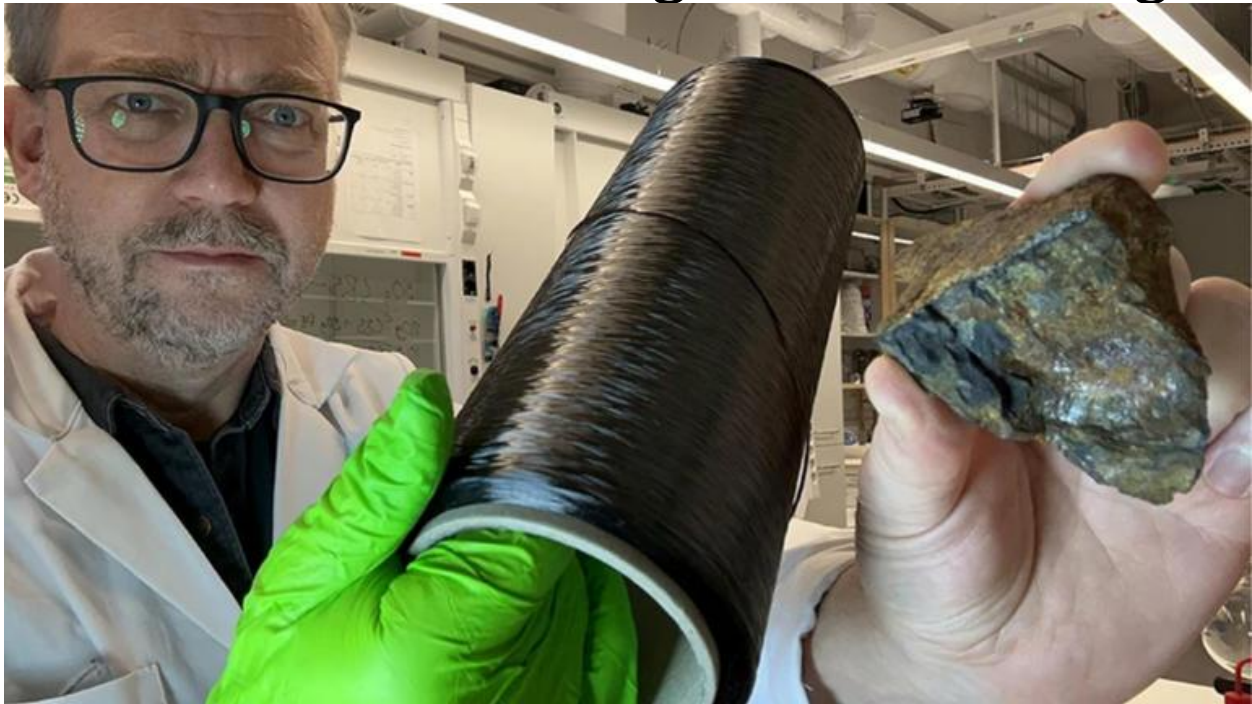
The battery of a Toyota electric vehicle.

But after many years of research, El-Zahab and his team figured out how to sidestep this crushing problem, and the answer is platinum. Adding nano-sized particles of this precious metal to the sulfur-side of the battery stabilizes performance by preventing damaging reactions, likely making the lithium-sulfur chemistry a viable option going forward. Keeping costs in check, not much platinum is needed, just about 0.02 percent of the total battery needs to be this element. El-Zahab likens this to adding a pinch of salt to your food, a little bit goes a long way.

As FIU postdoctoral researcher Aqsa Nazir also explained in the same story, “We achieved a 92-percent retention after 500 charging cycles, which means the battery is nearly as good as new.”

Currently, the lithium-sulfur battery developed by El-Zahab and his team is being tested by third parties. With any luck, this new design will hold up to rigorous evaluation, so it can quickly be commercialized. If it can reduce costs, increase energy density, and go the distance, future electric vehicles could greatly benefit from lithium-sulfur battery technology.

## **Sweden creates EV battery power from carbon fibers, reducing need for mining**



Sweden creates EV battery power from carbon fibers, reducing need for mining

Researchers at KTH Royal Institute of Technology have announced a significant breakthrough in sustainable nanomaterial synthesis. They have developed a reproducible and scalable method for producing graphene oxide (GO) nanosheets from commercial carbon fibers.

This development offers a greener alternative to traditional graphite mining. Graphene oxide is a versatile nanomaterial with a wide range of applications for several industries, including electric vehicles.

“The future of auto manufacturing will build on battery-based power, and the question is where the graphite will be sourced? They are going to need alternatives,” highlighted Professor Richard Olsson, who led the research.

GO is typically derived from mined graphite, and this process often involves harsh chemicals and can lead to inconsistencies in the final product.

## **Exfoliating carbon fibers**

The KTH researchers’ method addresses these issues by utilizing readily available carbon fibers as a starting material.

The team achieved this by exfoliating carbon fibers using nitric acid. This process yields high quantities of one-atom-thick sheets of [graphene oxide](#) with properties comparable to commercially available graphene oxide derived from mining.

The researchers demonstrated the process using carbon fibers derived from polyacrylonitrile (PAN), a widely available polymer. It suggests the method could be adapted for other sources like biomass or forest industry byproducts.

“The core of graphite battery functionality can be found in the layered graphene inside, which can be harvested from commercial carbon fibers using this method,” added Olsson.

## **Electrochemical oxidation**

The innovative process involves electrochemical oxidation in a water and nitric acid bath.

“The bath acts as a conductor and when an electric current is sent through carbon fiber, the material begins to lose electrons which transforms the surface

much the same way that oxidization appears as rust on a car,” explained the team in a [press release](#).

This transforms the surface and causes layers of nanoscale graphene oxide to peel off.

The study found that a 5 percent nitric acid solution was optimal for creating nanosheets ranging from 0.1 to 1 micrometer in size, with a uniform thickness of approximately 0.9 nanometers.

Interestingly, these GO nanosheets exhibited circular and elliptical shapes, unlike the polygonal shapes typically seen in GO from mined graphite.

## Highly efficient and scalable method for getting graphene

“Compared to existing synthetic methods, the new approach delivers a high yield of 200 milligrams of GO per gram of carbon fiber,” said the press release.

“This efficient conversion rate makes it viable for [large-scale production](#), addressing a key challenge in nanomaterial synthesis.”

The researchers used advanced techniques to analyze the properties and structure of the synthesized nanosheets, confirming their quality.

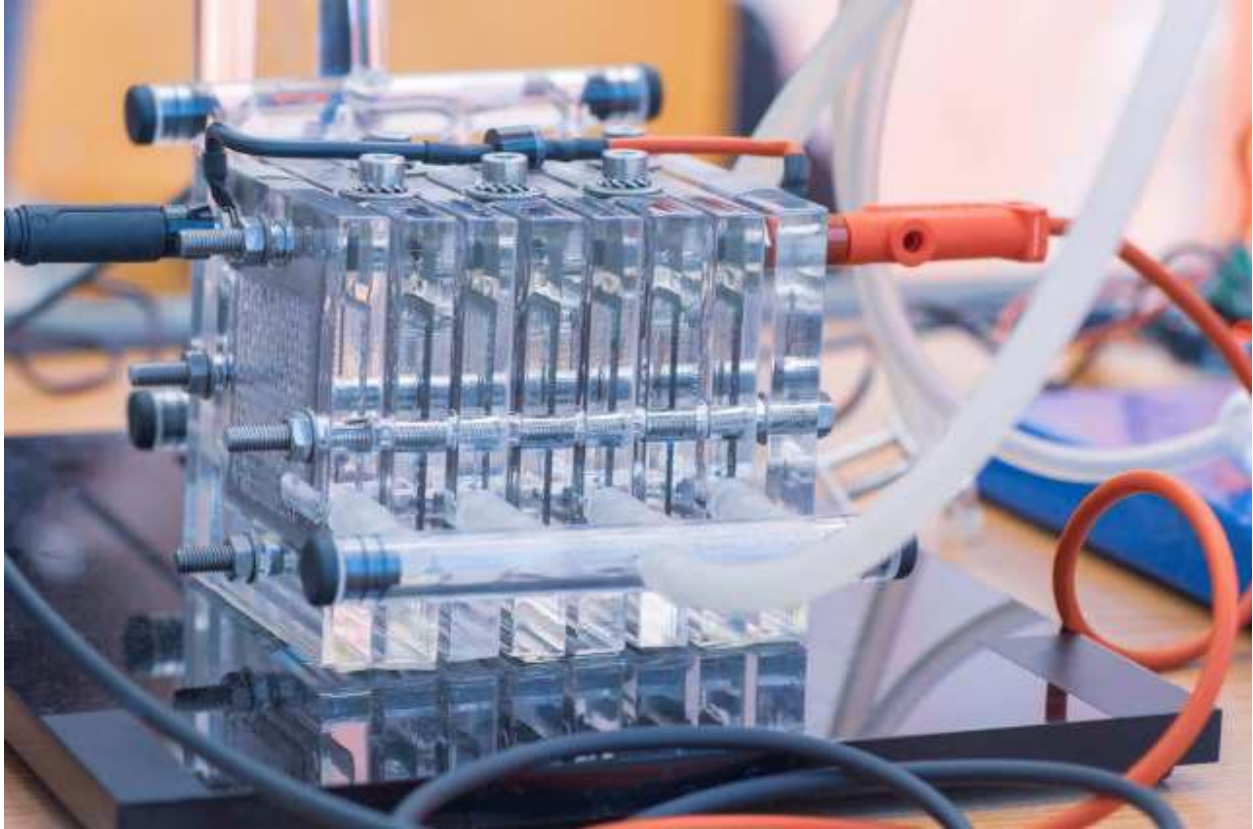
They also developed effective methods for removing protective polymer coatings from commercial carbon fibers prior to oxidation.

“The study also explored methods to remove protective polymer coatings from commercial carbon fibers before oxidation, heating at 1076 degree Fahrenheit (580°C) for two hours and shock-heating to 2192 degree Fahrenheit (1200°C) for three seconds—both proving effective,” concluded the researchers.

[The study](#) revealed the importance of electrical conduction within the fibers for the electrochemical exfoliation process.

The next steps for the research team include exploring biobased carbon fiber sources and further investigating the underlying mechanisms of the process.

# Scientists make stunning breakthrough in battery efficiency — here's how it could reshape transportation



The new battery achieves an unprecedented energy density.

A game-changingly efficient [next-generation battery](#) could soon shake up the energy [tech](#) sector.

Researchers at the University of Science and Technology of China [published a paper](#) saying they have developed a lithium-hydrogen (Li-H) prototype that could have significant benefits for [electric vehicle](#) range, the battery duration of devices, and renewable energy storage.

Through innovative testing, the prototype was designed with three key parts: a lithium metal anode for storing and releasing energy; a platinum-coated layer, which allows hydrogen to function as the cathode; and a solid electrolyte (LATP), which allows lithium ions to move smoothly while keeping the battery stable.

This battery uses hydrogen as the cathode, whereas most hydrogen-based batteries use the element as the anode. With hydrogen as the anode, the battery is usually limited in voltage and energy storage capacity. Using hydrogen as the cathode and lithium as the anode overcomes these limitations, the researchers said.

And the results speak for themselves. This battery achieves an unprecedented energy density of 2825 watt-hours per kilogram and a 99.7% round-trip efficiency, according to [Interesting Engineering](#). In English, this means that it can hold a lot of energy and retains nearly all that energy during its charge and discharge cycles.

But are these numbers truly that impressive? Short answer: they are, though more rigorous testing in more practical applications will be needed to take the science here to a more proven scale.

On average, common batteries, such as nickel-cadmium (NiCd) and lithium-ion (Li-ion), only have an energy density of 45-80 Wh/kg and 150-300 Wh/kg, respectively, according to [Battery Skills](#). In terms of round-trip efficiency, most batteries run between [70% to over 90%](#), depending on the type of battery, according to MIT Professor Ahmed Ghoniem.

These are truly exciting times for the eco-friendly energy sector, especially considering the technology's potential applications.

For [electric vehicles](#), a high energy density battery could mean longer driving ranges on a single charge. In turn, this translates to less energy consumption, helping curb pollution and improve air quality. The battery's high efficiency and capacity also make it a [promising storage solution for solar](#) and wind energy.

As innovations like the Li-H battery drive more affordable energy forward and companies like BCA Industries are making strides toward similar goals, there's never been a better time to embrace eco-friendly energy practices.

# Breakthrough lithium-sulfur battery retains 601 mAh/g even after 300 cycles

Lithium-sulfur batteries (LSBs) offer a promising alternative to lithium-ion batteries, with a high capacity of 1675 mAh/g and 2500 Wh/kg energy density.

**Updated:** Mar 11, 2025

The world relies on lithium-ion (Li-ion) batteries to power a wide range of devices, including electronics, wireless headphones, handheld tools, household appliances, electric vehicles, and energy storage systems.

However, as traditional cathode electrodes near their theoretical capacity limits, scientists are intensifying efforts to develop alternative energy storage solutions.

Redefining energy storage, lithium-sulfur batteries (LSBs) – which utilize lithium as the negative electrode and sulfur as the positive – emerge as a powerful alternative, providing a high capacity of 1675 mAh/g and 2500 Wh/kg energy density.

Yet, despite their potential, LSBs face key challenges, including poor conductivity, severe volume expansion, and the “[shuttle effect](#).” Insulative sulfur intermediates, such as  $\text{Li}_2\text{S}_2$  and  $\text{Li}_2\text{S}$ , hinder ion transport, the cathode expands by 80% during cycling, and [polysulfide shuttling](#) causes self-discharge, all reducing efficiency and lifespan.

To address these issues, a research team from Shanghai Jiao Tong University in China developed a metal-organic framework-derived (MOF-derived) hierarchical porous  $\text{TiO}_2@\text{NPC}$  structure, combining titanium dioxide and nanoporous carbon.

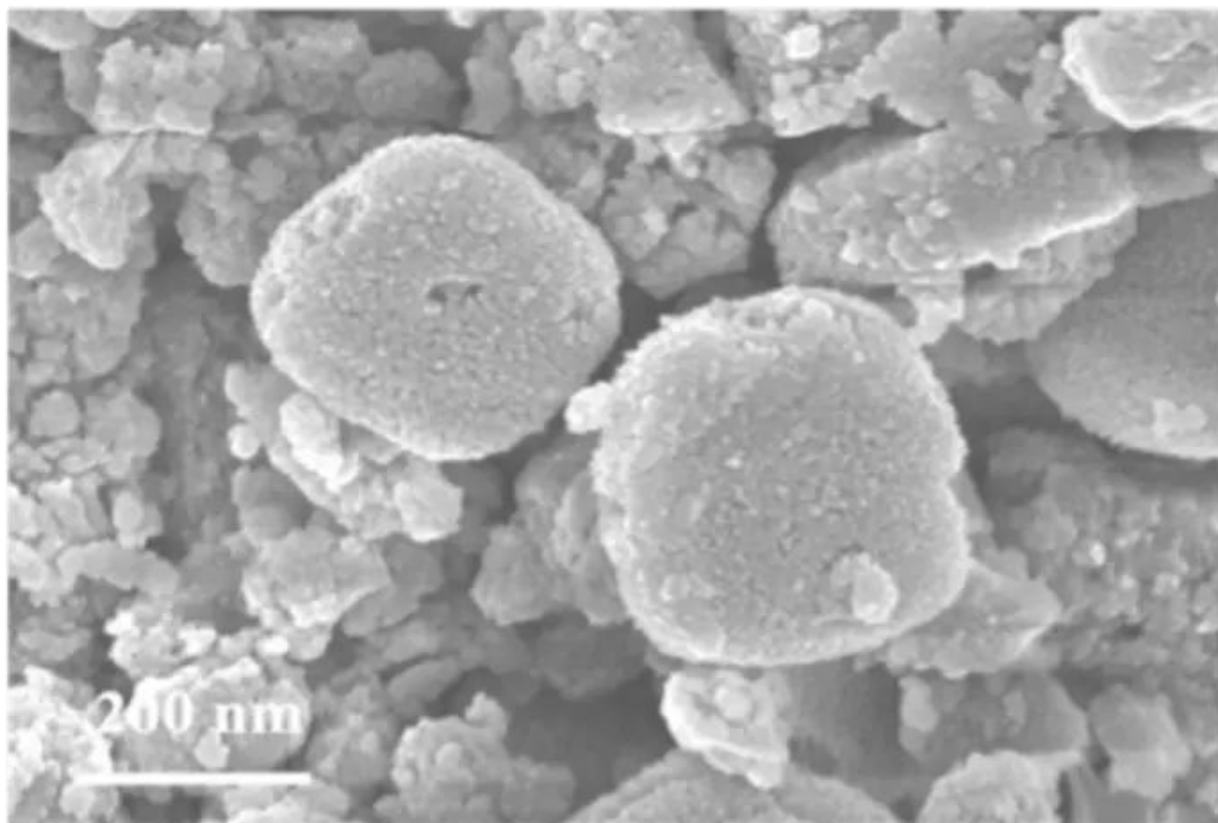
The design then laid the foundation for a  $\text{TiO}_2@\text{NPC}@\text{S}$  cathode with high sulfur loading, which significantly boosts conductivity, enhances stability, and maximizes sulfur retention.

## Developing the cathode material

In the initial stage of the multi-step preparation process, scientists synthesized MOF precursors by stirring phthalic acid and tetrabutyltitanate in a mixture of N, N-dimethylformamide, and methanol at room temperature. This was followed by ultrasonic treatment and vigorous stirring to ensure proper precursor formation.

“The mixture was then heated in a hydrothermal kettle at 155°C [311°F] for 20 hours, and after washing and drying, the MOFs precursors were obtained,” the university says. “These precursors were carbonized at 500°C [932°F] for 12 hours under a nitrogen atmosphere in a high-temperature tube furnace to form TiO<sub>2</sub>@NPC.”

Finally, the researchers combined TiO<sub>2</sub>@NPC with sublimed sulfur in a 3:7 ratio, sealed it in a vacuum, and heated it at 320°F for 12 hours to form TiO<sub>2</sub>@NPC@S.



The MOF-derived TiO<sub>2</sub>@NPC@S composite has a hierarchical porous structure.

Credit: [Carbon Future, Tsinghua University Press](#)

The team used advanced characterization techniques to analyze the material, with SEM and TEM imaging – Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), the two most common types of electron microscopy – showing a 3D porous structure that effectively retained sulfur.

“After sulfur storage, the pores in TiO<sub>2</sub>@NPC@S appeared filled, indicating successful sulfur infiltration and immobilization,” the university continues. “[XRD analysis](#) [X-ray diffraction] confirmed the anatase structure of TiO<sub>2</sub>@NPC, and the weak sulfur-related diffraction peaks in TiO<sub>2</sub>@NPC@S suggested good sulfur dispersion.”

The X-ray diffraction detected strong O-S and Ti-S bonds, stabilizing sulfur and reducing the shuttle effect. Meanwhile, a thermogravimetric analysis (TGA) measured the sulfur content at 64.09%, while the Brunauer–Emmett–Teller (BET) calculation revealed a

multi-level pore structure with a  $155.34 \text{ m}^2/\text{g}$  surface area, enhancing electrolyte infiltration and sulfur expansion accommodation.

## Future potential

Electrochemical tests confirmed the  $\text{TiO}_2@\text{NPC}@S$  [electrode's](#) strong performance, with charge-discharge experiments at 0.5 C – a rate where the battery discharges half its full capacity per hour – showing an initial capacity of 1327.35 mAh/g.

“Even after 300 cycles, the capacity remained at 601.54 mAh/g, with an average capacity decay of only 0.16% per cycle, far surpassing the commercial Y-50@S material,” the university concludes in a [press release](#). “In rate performance tests, at 1 C, the capacity was 928 mAh/g, and at 1.5 C, it reached 743 mAh/g, while the Y-50@S electrode's capacity declined rapidly at higher rates.”

Electrochemical impedance spectroscopy (EIS) tests showed that  $\text{TiO}_2@\text{NPC}@S$  had lower charge-transfer resistance, allowing faster reactions and [improved conductivity](#).

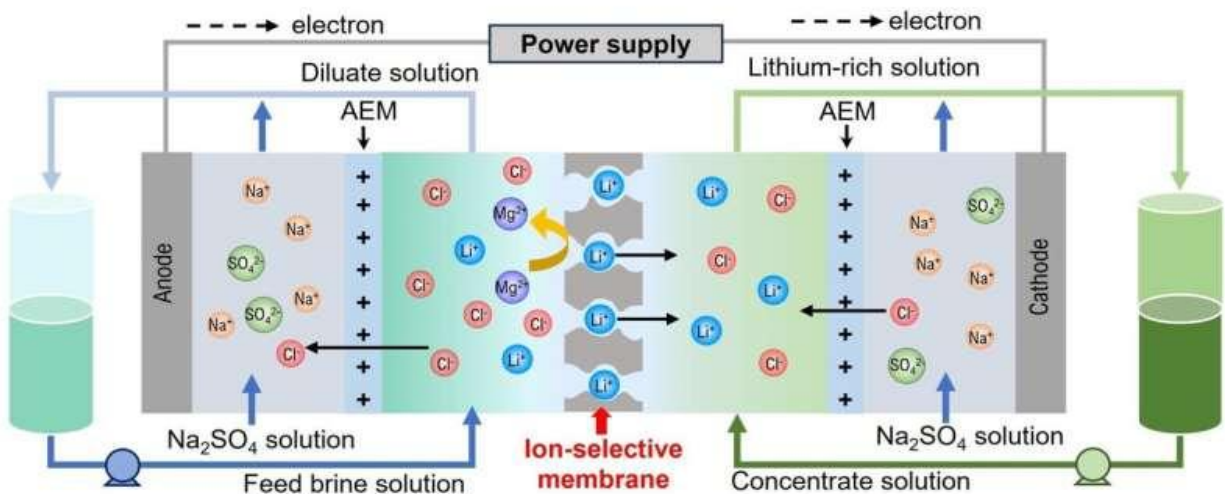
This research introduces a new approach to improving LSB cathodes. The researchers hope this cathode material will advance high-performance energy storage and drive the future of sustainable energy.

The study has been [published](#) in the journal *Carbon Future*.

MARCH 12, 2025

# Lithium needed for the battery revolution could be harvested from saltwater lakes thanks to a new membrane

by Ian Mundell, [Imperial College London](#)



Schematic diagram of selective electrodesialysis process for lithium extraction from brine solution. Credit: *Nature Water* (2025). DOI: 10.1038/s44221-025-00398-8

Demand for lithium is rising due to its use in batteries for mobile devices, cars and clean energy storage. Securing access to natural deposits of the mineral is now a matter of strategic importance, but lithium can be found elsewhere in nature.

As an alternative to mining, Imperial researchers have created a technology that could be used to efficiently extract it from saltwater sources such as salt-lake brines or geothermal brine solutions.

Conventional [lithium](#) extraction from brines takes months and uses significant amounts of water and chemicals, generating greenhouse gas emissions in the process. The alternative developed by Dr. Qilei Song and his team in the Department of Chemical Engineering uses a membrane that separates lithium from [salt water](#) by filtering it through tiny pores.

The usual shortcoming with this approach is that the pores also let through magnesium and other contaminants, but the team have developed a class of special polymers that are highly selective for lithium. Details of the method, and how it can be scaled up for practical application, have just been [published](#) in the journal *Nature Water*.

## Polymers of intrinsic microporosity

For more than a decade, Dr. Song has been working on a new generation of synthetic [polymer](#) membranes, based on materials known as polymers of intrinsic microporosity (PIMs). These polymers are shot through with tiny, hour-glass-shaped micropores that provide ordered channels through which small molecules and ions can travel.

In this new study, Dr. Song's team fine-tuned the micropores to become highly selective for lithium. Used in an electrodialysis device, the lithium ions are effectively pulled through the membrane micropores by an electrical current, while larger magnesium ions are left behind.

Tested on simulated salt-lake brines, these PIM membranes were highly selective for lithium, and produced high-purity battery-grade lithium carbonate.

If these membranes are to be of practical use, however, they must be produced in large quantities. Fortunately, the polymers are soluble in common solvents and can be turned into membranes using established industrial techniques.

"The polymer synthesis routes are based on commercially available monomers and simple chemical modifications, which makes scaling up the membranes relatively easy," said Dingchang Yang, a Ph.D. student in Dr. Song's group who led the experimental work. They can also be incorporated easily into commercial [membrane](#) modules and combined with other separation processes, which will also speed their use.

## Commercial prospects

Imperial has filed patent applications for these membranes and a range of different uses, including lithium extraction. Dr. Song is now working with Imperial Enterprise and ChemEng Enterprise, the technology transfer initiative of the Department of Chemical Engineering, to explore potential commercialization of the technology.

"We are in the process of establishing a climate tech company and are keen to build partnerships with companies to extract lithium at a large scale using real brine solutions," he said.

Isolating lithium is just the beginning of the potential for these high-selectivity membranes. "This technology has tremendous potential in a variety of commercially important areas, from energy storage to [water purification](#) to recovery of critical materials in a [circular economy](#)," said Professor Sandro Macchietto, Director of Enterprise in the Department of Chemical Engineering.

One line of investigation will apply the ion-exchange polymers and selective electro dialysis to the extraction of copper and other [metal ions](#) from mining process waters. "This links well with the sustainable extraction of critical materials, which is being pursued by the Rio Tinto Center for Future Materials at Imperial," Dr. Song said.

**More information:** Dingchang Yang et al, Solution-processable polymer membranes with hydrophilic subnanometre pores for sustainable lithium extraction, *Nature Water* (2025). DOI: [10.1038/s44221-025-00398-8](https://doi.org/10.1038/s44221-025-00398-8)

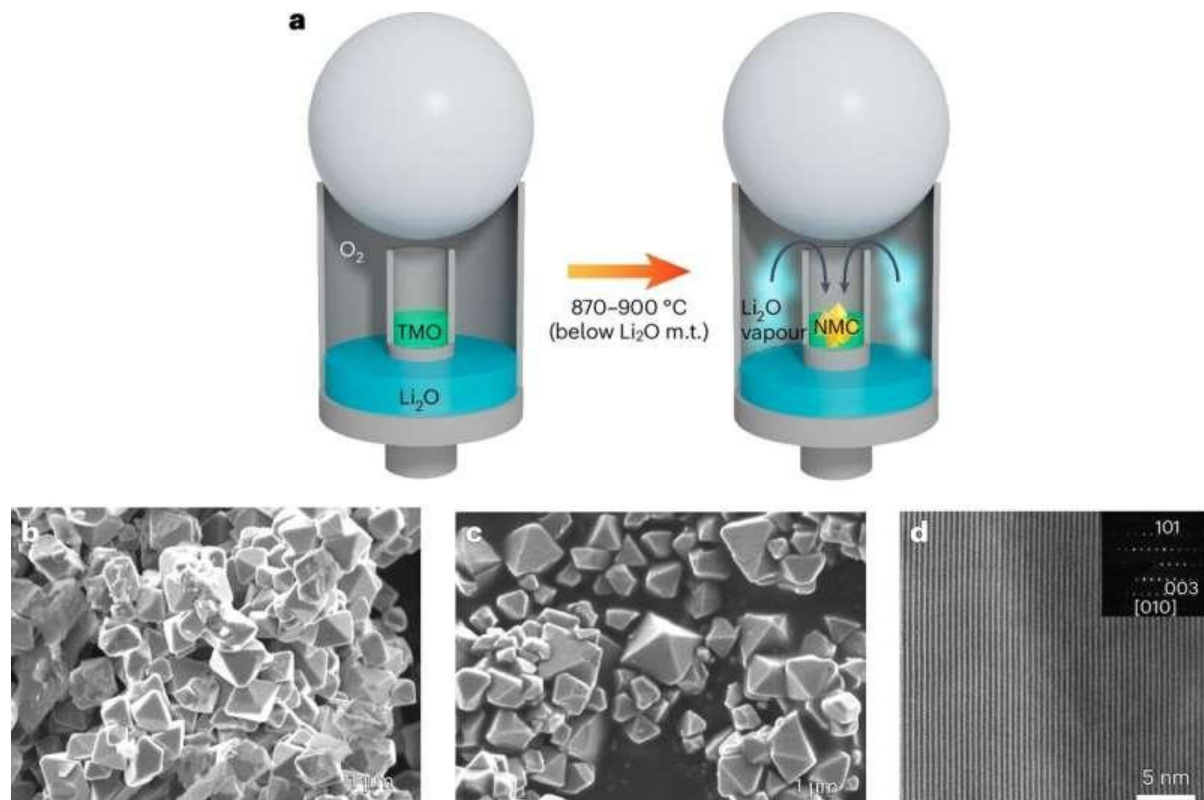
**Journal information:** [Nature Water](#)  
Provided by [Imperial College London](#)

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APRIL 15, 2025

# Lithium oxide sublimation opens doors for cheaper and quicker battery manufacturing

by JoAnna Wendel, [Pacific Northwest National Laboratory](#)



Vapor study between  $\text{Li}_2\text{O}$  and TMO oxide precursors. Credit: *Nature Energy* (2025). DOI: [10.1038/s41560-025-01738-4](https://doi.org/10.1038/s41560-025-01738-4)

A common lithium salt has revealed new possibilities for manufacturing cheaper, longer-lasting battery materials.

The discovery centers on sublimation, a commonly known process whereby under the right conditions, a solid turns directly into a vapor. Sublimation is what creates the tail of a comet as it flies by the sun. As the comet's icy shell heats up, the ice instantly becomes vapor, instead of first melting into liquid water.

Now, scientists at the U.S. Department of Energy's Pacific Northwest National Laboratory have taken a page out of nature's playbook. In a new finding [published](#) in *Nature Energy*, the PNNL-led team showed that vapor from [lithium oxide](#) ( $\text{Li}_2\text{O}$ ) sublimation accelerates a chemical reaction that forms single crystals when mixed with nickel-rich precursors. Moreover, the sublimation happens at just one atmosphere of pressure, the everyday pressure felt at sea level. Single-crystal battery materials are thought to help batteries last longer.

"The discovery offers a potentially faster, more efficient, and cheaper way to scale up the manufacturing of nickel-rich lithium-ion batteries," said Jie Xiao, co-author on the paper and a Battelle Fellow who holds a joint appointment with PNNL and the University of Washington. At UW, Xiao is the university's Boeing Martin Professor in the Mechanical Engineering Department.

"The research shows us how [materials science](#) can be applied to simplify the manufacturing process," Xiao continued.

Scientists recently discovered that the sublimation of lithium oxide, when mixed with nickel-rich cathode precursors, creates a single-crystal structure that could be used in longer-lasting batteries. The new work could also help decrease the cost of battery manufacturing. Credit: Sara Levine / Pacific Northwest National Laboratory

## The promise of nickel

Creating materials for batteries is a little like baking: Combine the right ingredients, apply heat, and produce something new. For batteries, researchers hunt for materials to make positive and negative electrodes of a battery (sometimes referred to as cathodes and anodes, respectively). Positive electrodes work by accepting ions and electrons, which creates the flow of electricity that powers devices like flashlights, laptops, cell phones, or even cars and data centers.

As demand for devices with [rechargeable batteries](#) grows, scientists are constantly looking for materials that can store more energy and last longer. Conventional lithium-ion batteries are limited by cost and how much energy they can hold, Xiao said. To reduce the cost, cheaper nickel and manganese are often mixed with cobalt into the battery material.

Recently, researchers including Xiao's PNNL team have been studying how to cost-effectively incorporate even more nickel into battery cathodes. Nickel can store more energy than cobalt, so increasing the amount of nickel in a [lithium-ion battery](#) makes the materials

more cost-effective. Nickel may also help reduce the cost of scaling up cathode manufacturing.

But despite its benefits, working with nickel still presents a challenge, Xiao said. Nickel-rich lithium cathode material tends to form as agglomerations known as "polycrystals," like a cookie packed with chocolate chips. Boundaries between the crystals—like the boundary between the cookie and the chocolate chips—become weaker as the battery discharges and charges. Over time, these weaknesses lead to cracking, which degrades the battery and shortens its lifetime.

"You can imagine all those tiny particles are agglomerated together, and they get pushed and pulled as the battery charges and discharges," Xiao said. "The movement can create cracks, which weakens the battery."

In the past five years, Xiao and her colleagues have been searching for materials that form single-crystal structures, like a plain chocolate cookie. The chocolate is still there, but it's evenly distributed through the cookie rather than packed in clumps.

"Single-crystal cathodes don't have the vulnerabilities that arise from polycrystal structures," Xiao said. "So, we hope single crystals will mitigate and eventually eliminate all the big challenges in nickel-rich cathode materials."

## The mystery of sublimation

Over the last few years, Xiao's team has been exploring different lithium salts supplied by industry partner Albemarle Corporation. Mixing these salt ingredients, or precursors, with nickel-rich precursors produces cathode material. One of the most common production methods is to melt the lithium salt, which then reacts with the nickel-rich precursor. For this process, researchers have preferred lithium hydroxide (LiOH) because it has a low melting point.

In contrast, Li<sub>2</sub>O has a [high melting point](#) at 1,438 degrees Celsius, so it's rarely used for cathode material synthesis. But when experimenting with Li<sub>2</sub>O in Xiao's materials synthesis lab at PNNL, something surprising happened: when combining the nickel-rich precursor with Li<sub>2</sub>O at temperatures around 900 degrees Celsius, single-crystal cathode material readily formed.

Xiao and her colleagues replicated the reaction over and over, trying to find the mechanism. Eventually, they turned to their industry partner Thermo Fisher Scientific, who studied the reaction under an instrument called a MicroReactor. With those observations and a newly designed experiment, the team was able to successfully reveal the sublimation phenomenon.

"We are excited to record the reaction between Li<sub>2</sub>O and the precursor in the microscope," said Libor Novák, the inventor of the MicroReactor at Thermo Fisher Scientific.

The new research confirms the mechanism is driven by  $\text{Li}_2\text{O}$  sublimation. In the baking scenario, it would be like combining the cookie dough with vaporized chocolate. When you cut the cookie in half, there are no chunks of chocolate, just a chocolate cookie with no distinct boundaries.

"The vapor can penetrate everywhere, right into the other precursors' pores or surface and immediately react," Xiao said. "Single crystals form much faster in the presence of those vapors."

The team further applied the  $\text{Li}_2\text{O}$  sublimation phenomenon to directly convert spent polycrystals into single crystals simply through a mixing-and-heating process. The successful formation of new single crystals shows that  $\text{Li}_2\text{O}$  salt considerably simplifies the recycling process of spent or waste polycrystals. Especially for those scraps from the production line, they can be quickly "remade" into high-performance single crystals by this salt ingredient, Xiao said.

What's more, the new single crystals, either from fresh precursors or from spent polycrystals, withstood 1,000 charge/discharge cycles—meaning they can remain stable for long periods of time.

## Potential boon to manufacturing

With the time and energy savings, plus the high performance of  $\text{Li}_2\text{O}$ -derived single crystals, the discovery provides a new way to manufacture single crystals. However, the team has more work to do before any batteries can be produced, Xiao said. Because  $\text{Li}_2\text{O}$  is not broadly used for materials synthesis, the cost to use it commercially is currently too high. However, Xiao noted that  $\text{Li}_2\text{O}$  is easily produced by processing other lithium salts, such as  $\text{LiOH}$ .

With industry partners, Xiao and her team are now working to scale up the process with lower manufacturing costs. The team hopes to provide [single crystals](#) to their strategic partners in 2026.

**More information:** Bingbin Wu et al, Unusual  $\text{Li}_2\text{O}$  sublimation promotes single-crystal growth and sintering, *Nature Energy* (2025). DOI: [10.1038/s41560-025-01738-4](https://doi.org/10.1038/s41560-025-01738-4)

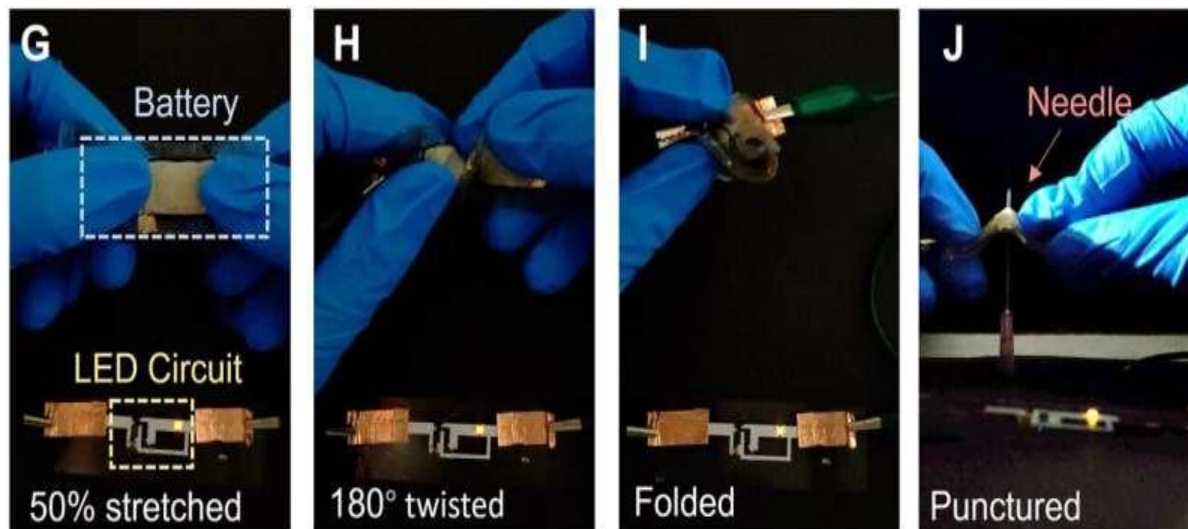
**Journal information:** [Nature Energy](#)

Provided by [Pacific Northwest National Laboratory](#)

APRIL 15, 2025

# Self-healing lithium battery stretches, survives punctures and cuts

by Bob Yirka , Tech Xplore



Stretchable aqueous Li-ion battery. (G) 50% stretched, (H) 180° twisted, (I) folded, and (J) punctured by a needle. Credit: *Science Advances* (2025). DOI: 10.1126/sciadv.adu3711  
A multidisciplinary team at the University of California, Berkeley, the Georgia Institute of Technology and the Hong Kong University of Science and Technology has developed a stretchable, self-healing lithium battery that remains stable after 500 charge/discharge cycles. In their [paper](#) published in the journal *Science Advances*, the group describes how they developed the battery and possible uses for it.

Over the past several years, scientists have been developing batteries for different types of applications. One such type is the stretchable battery, which could be used in wearable electronics. Recently, a team at Linköping University announced that they had developed [a fluid battery that can take any shape](#), allowing for its use in a wide variety of applications. In this new study, the team at UC Berkeley has developed a [stretchable battery](#) that also heals itself.

Stretchable Li-ion battery powering to a circuit consisting of an LED and a DC-DC converter while being mechanically stressed, including 50% stretching, 180° twisting, and folding. Credit: *Science Advances* (2025). DOI: 10.1126/sciadv.adu3711

To make the [new battery](#), the research team started with a zwitterionic polymer that had both a positive and [negative charge](#). With such polymers, water molecules bond with the charged parts while the lithium ions are attracted by the negative parts of plastic. The arrangement allows water to be tightly bound in the battery, reducing the risk of it splitting when voltage is applied, while still allowing lithium ions to be released when desired.

The team then added an [acrylic acid](#) as a cross-linker and a fluorine-free Li salt-based hydrogel electrolyte with a stability window of up to 3.11 volts. The design allowed it to pull water from the air, further reducing the possibility of splitting the water molecules when electricity was applied.

Stretchable Li-ion battery powering to a circuit consisting of an LED and a DC-DC converter while being through-punctured repeatedly by a needle at multiple locations. Credit: *Science Advances* (2025). DOI: [10.1126/sciadv.adu3711](https://doi.org/10.1126/sciadv.adu3711)

The resulting battery was just 19% water and was able to maintain stability in rooms with 50% humidity. The team tested its capabilities by attaching it to a circuit board running LED lights. It performed well for more than a month, with very little water splitting. Due to its ability to self-heal, it was also able to continue working after being stretched, punctured by needles, cut by razors and folded.

**More information:** Peisheng He et al, High-voltage water-scarce hydrogel electrolytes enable mechanically safe stretchable Li-ion batteries, *Science Advances* (2025). DOI: [10.1126/sciadv.adu3711](https://doi.org/10.1126/sciadv.adu3711)

**Journal information:** [Science Advances](#)

# Mercedes' Solid-State Battery Breakthrough Just Shifted The EV Playing Field

Who would have guessed that [Mercedes](#) would win the solid-state race? The German automaker recently [test-drove the world's first EV powered by a solid-state battery](#). To repeat, Mercedes is the first company in the history of cars to get a solid-state battery into an EV and make it drive. Granted, the company isn't yet mass-producing any all-solid-state batteries (ASSBs for short), One cannot overstate what a big deal this is. This could be the biggest change in EVs since a California-based startup called [Tesla](#) announced that it would sell electric cars.

In order to give you the most up-to-date and accurate information possible, the data used to compile this article was sourced from various manufacturer websites and other authoritative sources.

## Mercedes Just Put The First Solid-State Battery On The Road



Mercedes EQS SSB Prototype

- Mercedes just made history by driving the first-ever EV powered by a solid-state battery.
- Mercedes only recently got into solid-state batteries compared to many other companies. However, it entered a partnership with a battery company called Factorial Energy instead of trying to reinvent battery science on its own.
- Solid-state EV batteries have been in development for over a decade, but this is the first time any company has ever installed one into a car and then driven it.

Mercedes is the first company in the history of cars to drive a [solid-state-powered](#) EV. Granted, it was on a testing track and not on public roads. However, the simple act of bolting a battery into a car and driving it had seemed impossible until now. The automotive news was peppered with various announcements about [various solid-state breakthroughs](#), but for the longest time, it seemed like car companies were too busy writing solid-state press releases to actually work on the batteries. However, at long last, solid-state EV batteries have left the testing laboratory and gotten onto the pavement.

## Mercedes' Surprisingly Short History With Solid-State Batteries

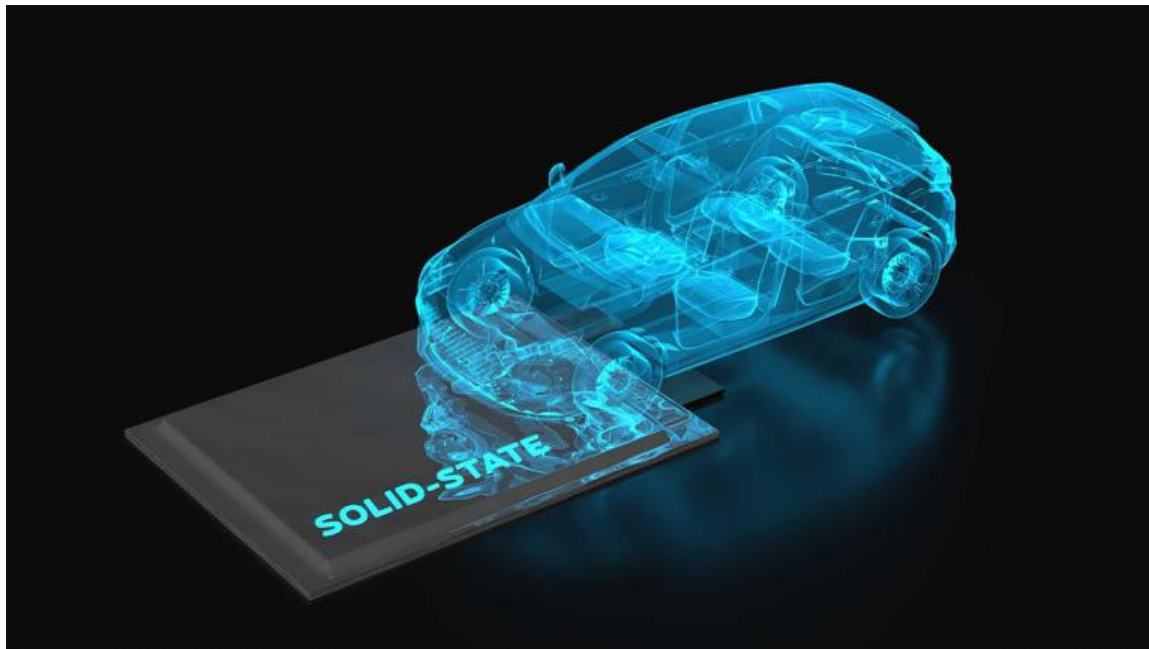


Mercedes-Benz

Mercedes is a relative latecomer to the solid-state industry. But instead of attempting to independently develop a solid-state battery in-house, it partnered with a US-based company called Factorial Energy. (Indeed, [many automakers have formed partnerships](#) with various pop-up battery companies.) As Mercedes' ASSB development gained momentum, it dubbed the project "Solstice" (There is no word on whether company executives chose the name as a subtle tribute to one of [the last Pontiac convertibles](#) before General Motors axed the brand.)

In September 2024, Mercedes announced that it would road-test its battery "in a few months." Of course, it was easy to be skeptical. Over the years, many companies have announced that they will have solid-state batteries in production or on the road by various dates— only for those dates to pass by with no batteries. However, in February 2025, Mercedes debuted the EQS solid-state concept car, driving it on a suitably picturesque track. (Who wants a groundbreaking car to be photographed in the back parking lot of the factory?)

## Why This Matters



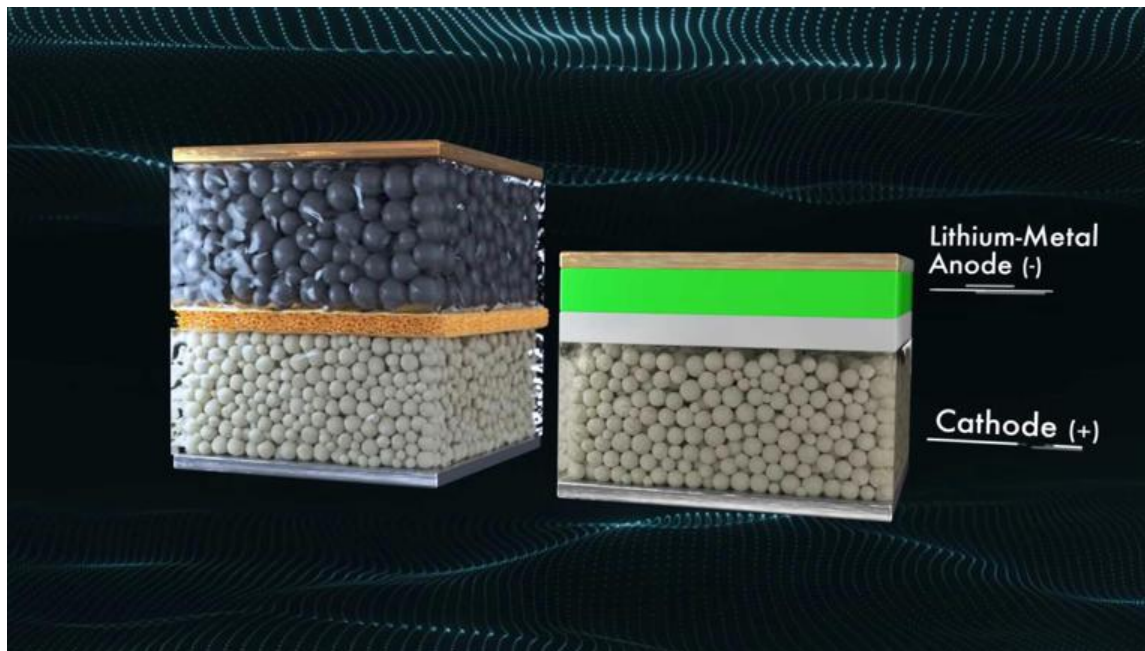
JLStock | Shutterstock

This is the first time a solid-state battery has ever gone into a car. Until now, solid-state batteries were almost turning into an expensive joke. [Various](#)

companies throughout the auto industry were spending painful amounts of money on solid-state batteries, but this massive effort had only yielded a flood of press releases.

It was starting to look like solid-state batteries were as impossible as fully autonomous self-driving cars that magically allow the driver to catch up on correspondence while the car commutes itself. After a while, no amount of clichéd phrases like "next-generation," "game-changing," or "sustainable" could make up for the lack of working vehicles. But now, at long last, a solid-state battery has powered a car— if only for a few rounds on a track.

## The Long Road to Solid-State Batteries



QuantumScape

- Although solid-state batteries are an old technology, until now they have only been used for very small devices.
- Toyota was the first car company to attempt to make solid-state batteries large enough to power EVs.
- Although Toyota had a head start of several years, other companies are catching up to it.

Solid-state batteries are an old technology. However, they have always been used for very small devices like hearing aids or pacemakers. When attempting to make larger solid-state batteries, [a lot of pesky physics problems flare up](#). Making a solid-state battery large enough to power a toy car has always been too difficult (or expensive), and making one large enough for a real car seemed daffy.

However, lithium-ion batteries (which are currently used in nearly all EVs) have too many shortcomings. Even as automakers spun up [lithium-ion](#) production lines (or signed contracts with outside battery suppliers), they were already looking for the next battery that would make lithium-ion obsolete.

## Toyota Started The Solid-State Revolution



Toyota

In 2012, Toyota announced that it would try to make a [solid-state battery big enough to power a car](#). At the time, the idea seemed almost preposterous. It was true then (and still is now) that [Toyota had enough profits](#) to launch any number of ill-advised projects, solid-state batteries included. Indeed, Toyota has been [pouring money into hydrogen cars](#) without feeling any financial strain. But even if Toyota could afford to let a project turn into a money pit, it took a long time for solid-state batteries to appeal to anyone else in the industry.

## The Battery Race Is Still Going



Nissan

Near the end of the 2020s, Toyota began announcing some tentatively promising results from its solid-state project. At this point, others in the auto industry began to [take solid-state batteries more seriously](#). Some companies, like [Honda](#), began [independently developing their own solid-state batteries](#), just like Toyota had. Other companies hastily went into partnership agreements with any battery companies they could find. Indeed, for a while, it seemed like anyone could start a battery company and lure automotive executives bearing contracts and money.

## Toyota Is Losing The Race It Started



Toyota

- Toyota was the first company to seriously research solid-state batteries. It's possible that no other company would have been interested in them without Toyota going there first.
- Today, other companies throughout the auto industry are rapidly developing their own solid-state batteries, while Toyota seems to have stalled.

No discussion of solid-state batteries would be complete without Toyota. The Japanese automaker [was the first in the industry](#) to get into solid-state battery development. Toyota's initial announcement about solid-state batteries was somewhat surprising because the company had shown little interest in EVs. Toyota had produced a few very small batches of all-electric Rav4s over the years, but it would not permanently add an EV to its lineup until ten years later when it introduced the [bZ4X](#).

## **Toyota Pioneered Solid-State EV Battery Research**



Toyota

When Toyota announced it would produce a solid-state battery in 2012, the announcement seemed almost preposterous. Solid-state batteries were already an old and well-understood technology, meaning that scientists already knew why making a car-sized one [was either impossible or close to it](#). Furthermore, this was coming from a company that seemed to have nearly no interest in EVs. (Indeed, Toyota [seemed more devoted to hydrogen cars](#) than battery-powered EVs.)

Toyota has one massive advantage over other automakers: it is one of the most profitable companies in the industry. The high cost of battery research would have sunk many other car manufacturers, but Toyota barely felt the financial pinch.

## **Toyota's Battery Development Stalled, And Other Companies Caught Up**

Although Toyota had several years of lead time, the rest of the auto industry eventually caught up with it. Today, Toyota's battery development seems to have almost stagnated. Things first looked uncertain when Toyota claimed it would have a battery on display at the 2020 Tokyo Olympics. When the games finally

happened in 2021 (they were delayed due to the pandemic), [Toyota was absent without comment](#).

In the years since, Toyota has quietly pushed its expected deployment date from 2027 to "2027 or 2028." Although the company's website has many pages of optimistic writing about solid-state batteries, there have been relatively few concrete announcements about battery progress. With Mercedes currently leading the solid-state race and [the rest of the auto industry close behind](#), Toyota can't afford to delay its batteries much more. It would be as embarrassing as introducing a hybrid car ten years after some other company created the first Prius.

## Mercedes May Have Just Driven The Most Important Concept Car In EV History



Mercedes-Benz

Mercedes just proved that solid-state batteries are possible. Up until now, solid-state batteries had been restricted to testing laboratories. Given the sheer amount of money and resources that had gone into the solid-state cause, it almost looked like solid-state batteries were impossible to drive for reasons that no one would admit to. All the promising laboratory tests like [Volkswagen's lifespan trials](#) seemed pointless in the absence of a working car. Mercedes may

have only driven its concept car a few times around a track, but it just brought the EV industry forward by several years.

## Solid-State Batteries Would Solve Most EV Problems



Rivian

Even if most people don't realize it, their biggest EVs complaints all go back to the battery. When we asked our own readers why [they don't want to own an EV](#), they cited things like short ranges, long charging times, and [the cost of battery replacement](#). Granted, there are a few dedicated people who would miss their [beloved clutch pedals](#) if they switched to an EV. People who test-drive EVs find that they love the "instant torque" more than they expected, even if (like most car buyers) they don't know the meaning of the word torque. EVs eliminate all worries about keeping the engine in its power band, but battery problems continue to keep people from buying them.

# Lithium-Ion Batteries Were Good Enough To Sell EVs, But They Have Too Many Shortcomings



William Clavey | TopSpeed

Solid-state batteries are poised to make current-generation batteries obsolete. However, it must be acknowledged that lithium-ion batteries made EVs viable. Of course, EVs are almost as old as horseless carriages. But before lithium-ion batteries, EVs (even late-20th-century models like General Motors' [EV1](#)) tended to have about the range of an ICE car running on fumes.

However, automotive scientists were already looking for something better than lithium-ion before the first lithium-ion EVs left the factory. [Various possible technologies](#) have been tried in laboratories, but Mercedes is the first company to get a truly next-generation battery onto the road.

## Science News

from research organizations

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### New fuel cell could enable electric aviation

May 27, 2025

Massachusetts Institute of Technology

*Date:*

*Source:*

*Summary:*

Engineers developed a fuel cell that offers more than three times as much energy per pound compared to lithium-ion batteries. Powered by a reaction between sodium metal and air, the device could be lightweight enough to enable the electrification of airplanes, trucks, or ships.

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Batteries are nearing their limits in terms of how much power they can store for a given weight. That's a serious obstacle for energy innovation and the search for new ways to power airplanes, trains, and ships. Now, researchers at MIT and elsewhere have come up with a solution that could help electrify these transportation systems.

Instead of a battery, the new concept is a kind of fuel cell -- which is similar to a battery but can be quickly refueled rather than recharged. In this case, the fuel is liquid sodium metal, an inexpensive and widely available commodity. The other side of the cell is just ordinary air, which serves as a source of oxygen atoms. In between, a layer of solid ceramic material serves as the electrolyte, allowing sodium ions to pass freely through, and a porous air-facing electrode helps the sodium to chemically react with oxygen and produce electricity.

In a series of experiments with a prototype device, the researchers demonstrated that this cell could carry more than three times as much energy per unit of weight as the lithium-ion batteries used in virtually all electric vehicles today. Their findings are being published today in the journal *Joule*, in a paper by MIT doctoral students Karen Sugano, Sunil Mair, and Saahir Ganti-Agrawal; professor of materials science and engineering Yet-Ming Chiang; and five others.

"We expect people to think that this is a totally crazy idea," says Chiang, who is the Kyocera Professor of Ceramics. "If they didn't, I'd be a bit disappointed because if people don't think something is totally crazy at first, it probably isn't going to be that revolutionary."

And this technology does appear to have the potential to be quite revolutionary, he suggests. In particular, for aviation, where weight is especially crucial, such an improvement in energy density could be the breakthrough that finally makes electrically powered flight practical at significant scale.

"The threshold that you really need for realistic electric aviation is about 1,000 watt-hours per kilogram," Chiang says. Today's electric vehicle lithium-ion batteries top out at about 300 watt-hours per kilogram -- nowhere near what's needed. Even at 1,000 watt-hours per kilogram, he says, that wouldn't be enough to enable transcontinental or trans-Atlantic flights.

That's still beyond reach for any known battery chemistry, but Chiang says that getting to 1,000 watts per kilogram would be an enabling technology for regional electric aviation, which accounts for about 80 percent of domestic flights and 30 percent of the emissions from aviation.

The technology could be an enabler for other sectors as well, including marine and rail transportation. "They all require very high energy density, and they all require low cost," he says. "And that's what attracted us to sodium metal."

A great deal of research has gone into developing lithium-air or sodium-air batteries over the last three decades, but it has been hard to make them fully rechargeable. "People have been aware of the energy density you could get with metal-air batteries for a very long time, and it's been hugely attractive, but it's just never been realized in practice," Chiang says.

By using the same basic electrochemical concept, only making it a fuel cell instead of a battery, the researchers were able to get the advantages of the high energy density in a practical form. Unlike a battery, whose materials are assembled once and sealed in a container, with a fuel cell the energy-carrying materials go in and out.

The team produced two different versions of a lab-scale prototype of the system. In one, called an H cell, two vertical glass tubes are connected by a tube across the middle, which contains a solid ceramic electrolyte material and a porous air electrode. Liquid sodium metal fills the tube on one side, and air flows through the other, providing the oxygen for the electrochemical reaction at the center, which ends up gradually consuming the sodium fuel. The other prototype uses a horizontal design, with a tray of the electrolyte material holding the liquid sodium fuel. The porous air electrode, which facilitates the reaction, is affixed to the bottom of the tray.

Tests using an air stream with a carefully controlled humidity level produced a level of nearly 1,700 watt-hours per kilogram at the level of an individual "stack," which would translate to over 1,000 watt-hours at the full system level, Chiang says.

The researchers envision that to use this system in an aircraft, fuel packs containing stacks of cells, like racks of food trays in a cafeteria, would be inserted into the fuel cells; the sodium metal inside these packs gets chemically transformed as it provides the power. A stream of its chemical byproduct is given off, and in the case of aircraft this would be emitted out the back, not unlike the exhaust from a jet engine.

But there's a very big difference: There would be no carbon dioxide emissions. Instead the emissions, consisting of sodium oxide, would actually soak up carbon dioxide from the atmosphere. This compound would quickly combine with moisture in the air to make sodium hydroxide -- a material commonly used as a drain cleaner -- which readily combines with carbon dioxide to form a solid material, sodium carbonate, which in turn forms sodium bicarbonate, otherwise known as baking soda.

"There's this natural cascade of reactions that happens when you start with sodium metal," Chiang says. "It's all spontaneous. We don't have to do anything to make it happen, we just have to fly the airplane."

As an added benefit, if the final product, the sodium bicarbonate, ends up in the ocean, it could help to de-acidify the water, countering another of the damaging effects of greenhouse gases.

Using sodium hydroxide to capture carbon dioxide has been proposed as a way of mitigating carbon emissions, but on its own, it's not an economic solution because the compound is too expensive. "But here, it's a byproduct," Chiang explains, so it's essentially free, producing environmental benefits at no cost.

Importantly, the new fuel cell is inherently safer than many other batteries, he says. Sodium metal is extremely reactive and must be well-protected. As with lithium batteries, sodium can spontaneously ignite if exposed to moisture. "Whenever you have a very high energy density battery, safety is always a concern, because if there's a rupture of the membrane that separates the two reactants, you can have a runaway reaction," Chiang says. But in this fuel cell, one side is just air, "which is dilute and limited. So you don't have two concentrated reactants right next to each other. If you're pushing for really, really high energy density, you'd rather have a fuel cell than a battery for safety reasons."

While the device so far exists only as a small, single-cell prototype, Chiang says the system should be quite straightforward to scale up to practical sizes for commercialization. Members of the research team have already formed a company, Propel Aero, to develop the technology. The company is currently housed in MIT's startup incubator, The Engine.

Producing enough sodium metal to enable widespread, full-scale global implementation of this technology should be practical, since the material has been produced at large scale before. When leaded gasoline was the norm, before it was phased out, sodium metal was used to make the tetraethyl lead used as an additive, and it was being produced in the U.S. at a capacity of 200,000 tons a year. "It reminds us that sodium metal was once produced at large scale and safely handled and distributed around the U.S.," Chiang says.

What's more, sodium primarily originates from sodium chloride, or salt, so it is abundant, widely distributed around the world, and easily extracted, unlike lithium and other materials used in today's EV batteries.

The system they envisage would use a refillable cartridge, which would be filled with liquid sodium metal and sealed. When it's depleted, it would be returned to a refilling

station and loaded with fresh sodium. Sodium melts at 98 degrees Celsius, just below the boiling point of water, so it is easy to heat to the melting point to refuel the cartridges.

Initially, the plan is to produce a brick-sized fuel cell that can deliver about 1,000 watt-hours of energy, enough to power a large drone, in order to prove the concept in a practical form that could be used for agriculture, for example. The team hopes to have such a demonstration ready within the next year.

Sugano, who conducted much of the experimental work as part of her doctoral thesis and will now work at the startup, says that a key insight was the importance of moisture in the process. As she tested the device with pure oxygen, and then with air, she found that the amount of humidity in the air was crucial to making the electrochemical reaction efficient. The humid air resulted in the sodium producing its discharge products in liquid rather than solid form, making it much easier for these to be removed by the flow of air through the system. "The key was that we can form this liquid discharge product and remove it easily, as opposed to the solid discharge that would form in dry conditions," she says.

Ganti-Agrawal notes that the team drew from a variety of different engineering subfields. For example, there has been much research on high-temperature sodium, but none with a system with controlled humidity. "We're pulling from fuel cell research in terms of designing our electrode, we're pulling from older high-temperature battery research as well as some nascent sodium-air battery research, and kind of mashing it together," which led to the "the big bump in performance" the team has achieved, he says.

The research team also included Alden Friesen, an MIT summer intern who attends Desert Mountain High School in Scottsdale, Arizona; Kailash Raman and William Woodford of Form Energy in Somerville, Massachusetts; Shashank Sripad of And Battery Aero in California, and Venkatasubramanian Viswanathan of the University of Michigan. The work was supported by ARPA-E, Breakthrough Energy Ventures, and the National Science Foundation, and used facilities at MIT.nano.

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# Passive infrared contact lenses allow people to see in the dark, even with their eyes closed

University of Science and Technology of China develops non-invasive lenses using nanoparticles for enhanced infrared vision.

From Cell Press 23/05/25 (first released 22/05/25)

Neuroscientists and materials scientists have created contact lenses that enable infrared vision in both humans and mice by converting infrared light into visible light.

Unlike infrared night vision goggles, the contact lenses, described in the Cell Press journal *Cell* on May 22, do not require a power source—and they enable the wearer to perceive multiple infrared wavelengths.

Because they're transparent, users can see both infrared and visible light simultaneously, though infrared vision was enhanced when participants had their eyes closed.

“Our research opens up the potential for non-invasive wearable devices to give people super-vision,” says senior author Tian Xue, a neuroscientist at the University of Science and Technology of China.

“There are many potential applications right away for this material.

For example, flickering infrared light could be used to transmit information in security, rescue, encryption or anti-counterfeiting settings.”

The contact lens technology uses nanoparticles that absorb infrared light and convert it into wavelengths that are visible to mammalian eyes (e.g., electromagnetic radiation in the 400-700 nm range).

The nanoparticles specifically enable detection of “near-infrared light,” which is infrared light in the 800-1600 nm range, just beyond what humans can already see. The team previously showed that these nanoparticles enable infrared vision in mice when injected into the retina, but they wanted to design a less invasive option.

To create the contact lenses, the team combined the nanoparticles with flexible, non-toxic polymers that are used in standard soft contact lenses.

After showing that the contact lenses were non-toxic, they tested their function in both humans and mice.

They found that contact lens-wearing mice displayed behaviors suggesting that they could see infrared wavelengths.

For example, when the mice were given the choice of a dark box and an infrared-illuminated box, contact-wearing mice chose the dark box whereas contact-less mice showed no preference.

The mice also showed physiological signals of infrared vision: the pupils of contact-wearing mice constricted in the presence of infrared light, and brain imaging revealed that infrared light caused their visual processing centers to light up.

In humans, the infrared contact lenses enabled participants to accurately detect flashing morse code-like signals and to perceive the direction of incoming infrared light.

“It’s totally clear cut: without the contact lenses, the subject cannot see anything, but when they put them on, they can clearly see the flickering of the infrared light,” said Xue.

“We also found that when the subject closes their eyes, they’re even better able to receive this flickering information, because near-infrared light penetrates the eyelid more effectively than visible light, so there is less interference from visible light.”

An additional tweak to the contact lenses allows users to differentiate between different spectra of infrared light by engineering the nanoparticles to color-code different infrared wavelengths.

For example, infrared wavelengths of 980 nm were converted to blue light, wavelengths of 808 nm were converted to green light, and wavelengths of 1,532 nm were converted to red light.

In addition to enabling wearers to perceive more detail within the infrared spectrum, these color-coding nanoparticles could be modified to help color blind people see wavelengths that they would otherwise be unable to detect.

“By converting red visible light into something like green visible light, this technology could make the invisible visible for color blind people,” says Xue.

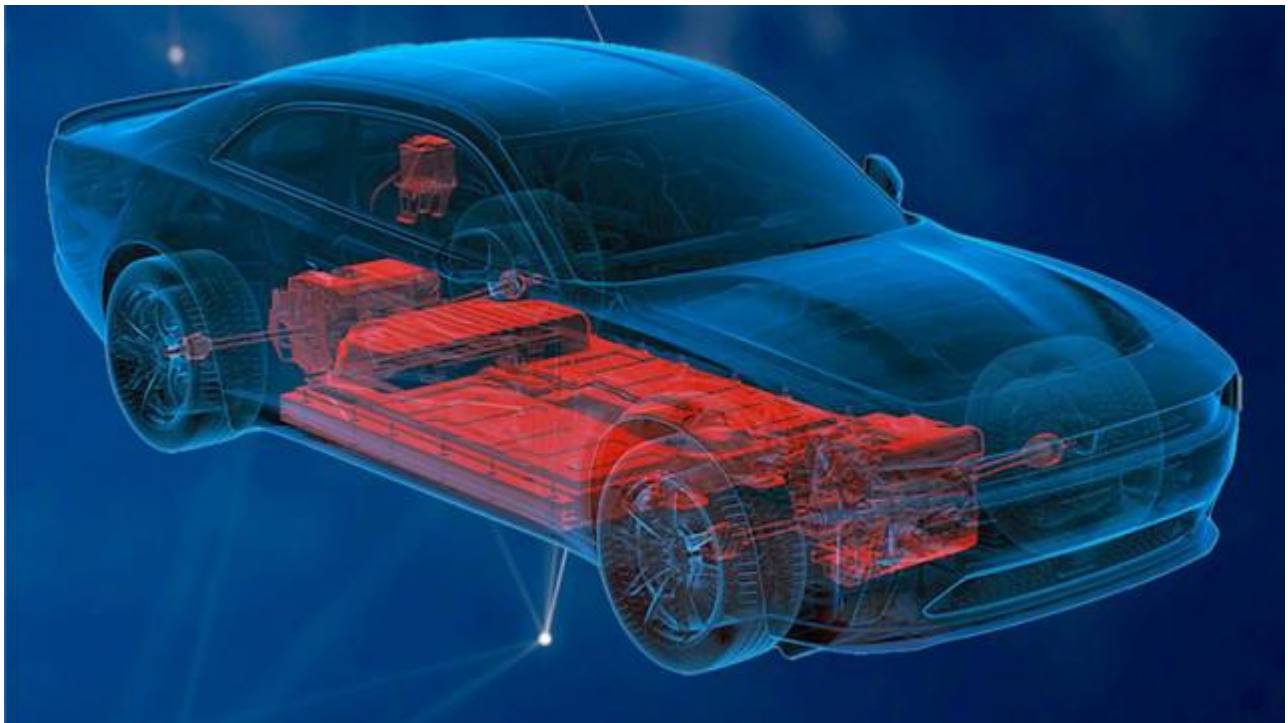
Because the contact lenses have limited ability to capture fine details (due to their close proximity to the retina, which causes the converted light particles to scatter), the team also developed a wearable glass system using the same nanoparticle technology, which enabled participants to perceive higher-resolution infrared information.

Currently, the contact lenses are only able to detect infrared radiation projected from an LED light source, but the researchers are working to increase the nanoparticles’ sensitivity so that they can detect lower levels of infrared light.

“In the future, by working together with materials scientists and optical experts, we hope to make a contact lens with more precise spatial resolution and higher sensitivity,” says Xue.

Study participant putting contacts in. Credit: Yuqian Ma, Yunuo Chen, Hang Zhao  
Researcher places infrared contacts in participant's eyes. Credit: Yuqian Ma, Yunuo Chen, Hang Zhao  
Preparation procedures for infrared contacts. Credit: Sheng Wang

## Automaker unveils next-gen EV breakthrough to eliminate charging delays and extend driving range: 'From research to reality'



For drivers, solid-state batteries could be an environmental tipping point.

In a major leap forward for the future of [electric vehicles](#), Stellantis — the global force behind brands like Dodge, Jeep, and Chrysler — has just validated a [technology](#) that could reshape the auto industry as we know it: solid-state EV batteries.

As Electrek [reported](#), this isn't just a science fair project anymore. Stellantis' recent validation of Factorial Energy's automotive solid-state battery cells signals that solid-state battery-run cars are coming to our driveways sooner than anyone could have imagined — possibly within the next few years.

Solid-state batteries promise to help solve the biggest headaches with today's EVs. Think: longer driving range, much faster charge, better safety, and greater durability — all in a smaller, lighter package.

That means fewer worries about running out of juice, quicker pit stops at chargers, and more affordable cars thanks to cheaper long-term maintenance. No oil changes. No routine fluid swaps. Just quieter, cleaner rides with no ozone-destroying tailpipe pollution.

They are just a third of the size of traditional Li-ion batteries and 40% lighter (580 pounds compared to 800 pounds). Factorial is pushing for a driving range of over 600 miles per charge, according to Electrek.

Solid-state batteries have been the holy grail for years because they ditch the liquid electrolyte found in traditional [lithium-ion batteries](#). Instead, they use a solid material that is far less flammable, making EVs even safer. And Stellantis isn't just dabbling.

The company has spent four years researching this breakthrough, partnering with Factorial Energy. Together, they've brought theory to action, with real-world testing now validating their designs in vehicles.

Today's battery-powered cars are already greener than gas guzzlers. [MIT found](#) that EVs, on average, produce less air pollution over their lifetimes than traditional vehicles.

And while some critics point to the mining required for battery materials, it's important to put things in perspective: We [dig up](#) around 16.5 billion tons of dirty fuels each year. Compare those numbers to the 30 million tons of minerals needed annually for [clean energy technology](#).

Plus, those minerals aren't burned into the atmosphere the way gas and oil are; they can be reused and recycled in future batteries.

According to Electrek, Siyu Huang, Factorial Energy CEO, said: "While optimizing one feature is simple, balancing high energy density, cycle life, fast charging, and safety in an automotive-sized battery with OEM validation is a breakthrough."

She added that the latest achievement is "bringing next-generation battery technology from research to reality."

For drivers, solid-state batteries could be an environmental tipping point. Think of EVs that can routinely drive 500 miles or more without blinking. Dodge muscle cars that roar with pure electric torque. Jeep off-roaders that silently crawl rugged trails — all without carbon pollution.

According to [Electrek](#), Stellantis plans to bring solid-state battery EVs to the market as soon as 2026. That's just around the corner, making now a perfect time to start thinking about making [your next car an EV](#).

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JUNE 12, 2025

The GIST

## Zinc–iodine battery delivers double performance of lithium-ion batteries

by [University of Adelaide](#) edited by [Gaby Clark](#), reviewed by [Robert Egan](#)

Researchers at the University of Adelaide have developed a new dry electrode for aqueous batteries which delivers cathodes with more than double the performance of iodine and lithium-ion batteries.

"We have developed a new [electrode](#) technique for [zinc](#)–iodine batteries that avoids traditional wet mixing of iodine," said the University of Adelaide's Professor Shizhang Qiao, Chair of Nanotechnology, and Director, Center for Materials in Energy and Catalysis, at the School of Chemical Engineering, who led the team.

"We mixed active materials as dry powders and rolled them into thick, self-supporting electrodes. At the same time, we added a small amount of a simple chemical, called 1,3,5-trioxane, to the electrolyte, which turns into a flexible protective film on the zinc surface during charging.

"This film keeps zinc from forming sharp dendrites—needle-like structures that can form on the surface of the zinc anode during charging and discharging—that can short the battery."

Aqueous zinc–iodine batteries offer unparalleled safety, sustainability, and cost advantages for grid-scale storage, but they suffer from performance issues compared to [lithium-ion batteries](#).

The team published their results in the journal [Joule](#).

"The new technique for electrode preparation resulted in record-high loading of 100 mg of active material per cm<sup>2</sup>," said the University of Adelaide's Han Wu, Research Associate, School of Chemical Engineering, from the team that worked on the study.

"After charging the pouch cells we made that use the new electrodes, they retained 88.6% of their capacity after 750 cycles and coin cells kept nearly 99.8% capacity after 500 cycles.

"We directly observed how the protective film forms on the zinc by using synchrotron infrared measurements."

High iodine loading and a robust zinc interface mean much more energy can be stored in each battery at a lower weight and cost. This could bring zinc–iodine batteries closer to real-world use for large-scale or grid storage.

There are several advantages of the team's invention over existing battery technology:

- Higher capacity: the dry electrodes pack more active material than wet-processed ones, which typically top out below  $2 \text{ mA h cm}^{-2}$ .
- Lower self-discharge and shuttle loss: dense dry electrodes reduce iodine escaping into the electrolyte and degrading performance.
- Better zinc stability: in situ protective film prevents dendrite growth, giving much longer cycle life.

"The new technology will benefit energy storage providers—especially for renewable integration and grid balancing—who will gain lower-cost, safer, long-lasting batteries," said Professor Qiao. "Industries needing large, stable energy banks, for example, utilities and microgrids, could adopt this technology sooner."

The team has plans to develop the technology further to expand its capabilities.

"Production of the electrodes could be scaled up by using reel-to-reel manufacturing," said Professor Qiao. "By optimizing lighter current collectors and reducing excess electrolytes, the overall system energy density could be doubled from around 45 watt-hours per kilogram ( $\text{Wh kg}^{-1}$ ) to around 90  $\text{Wh kg}^{-1}$ .

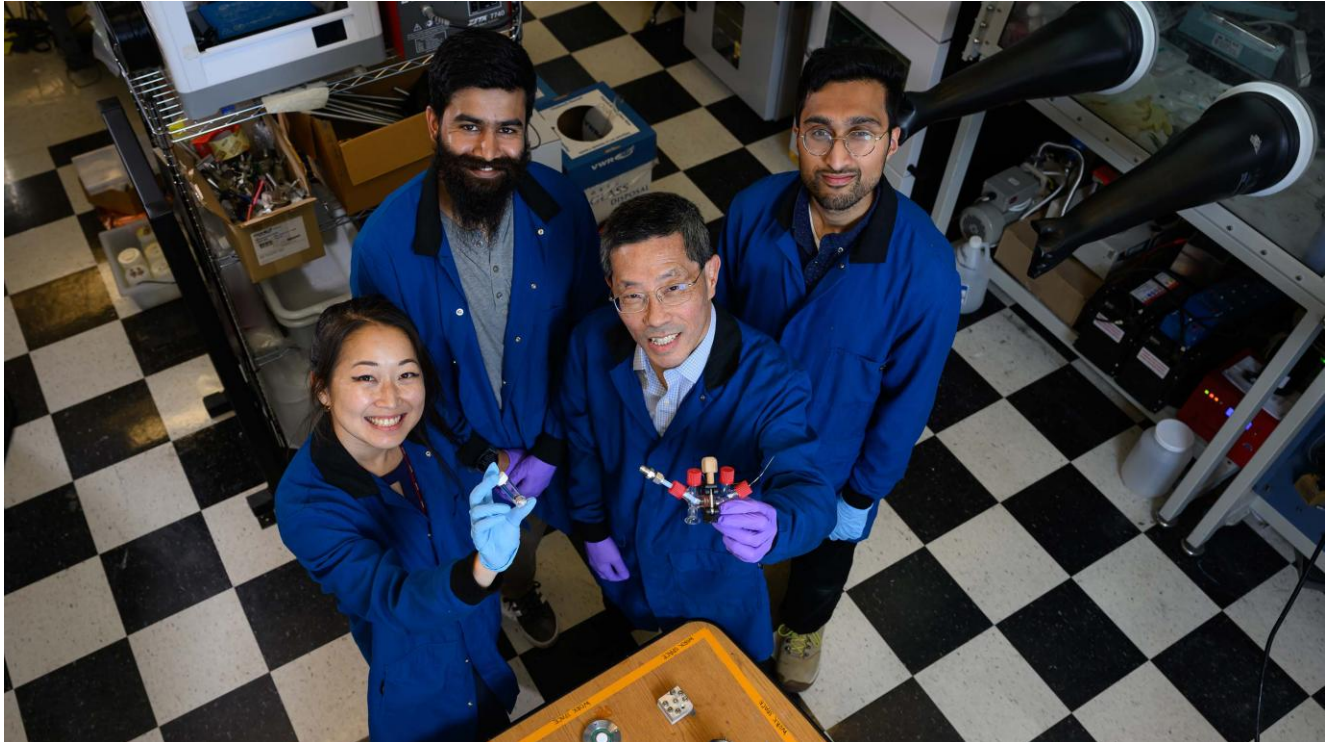
"We will also test the performance of other halogen chemistries such as bromine systems, using the same dry-process approach."

**More information:** Han Wu et al, Aqueous zinc-iodine batteries with ultra-high loading and advanced performance, *Joule* (2025). DOI: [10.1016/j.joule.2025.102000](https://doi.org/10.1016/j.joule.2025.102000)

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# A new sodium metal fuel cell could help clean up transportation

Fuel cells powered with the metal could provide a new source of electric power that's far more energy-dense than lithium-ion batteries. May 27, 2025



Yet-Ming Chiang, Karen Sugano, Sunil Mair, and Saahir Ganti-Agrawal. GRETCHEN ERTL/MITTR

A new type of fuel cell that runs on sodium metal could one day help clean up sectors where it's difficult to replace fossil fuels, like rail, regional aviation, and short-distance shipping. The device represents a departure from technologies like lithium-based batteries and is more similar conceptually to hydrogen fuel cell systems.

The sodium-air fuel cell was designed by a team led by Yet-Ming Chiang, a professor of materials science and engineering at MIT. It has a higher energy density than lithium-ion batteries and doesn't require the super-cold temperatures or high pressures that hydrogen does, making it potentially more practical for transport. "I'm interested in sodium metal as an energy carrier of the future," Chiang says.

Novel aircraft like eVTOLs could open new doorways for flight, but regulatory and technical barriers could mean conventional options hit the skies first.

The device's design, [published today in \*Joule\*](#), is related to the technology behind one of Chiang's companies, [Form Energy](#), which is building iron-air batteries for large energy storage installations like those that could help store wind and solar power on the grid. Form's batteries rely on water, iron, and air.

One technical challenge for metal-air batteries has historically been reversibility. A battery's chemical reactions must be easily reversed so that in one direction they generate electricity, discharging the battery, and in the other electricity goes into the cell and the reverse reactions happen, charging it up.

When a battery's reactions produce a very stable product, it can be difficult to recharge the battery without losing capacity. To get around this problem, the team at Form had discussions about whether their batteries could be refuelable rather than rechargeable, Chiang says. The idea was that rather than reversing the reactions, they could simply run the system in one direction, add more starting material, and repeat.

Ultimately, Form chose a more traditional battery concept, but the idea stuck with Chiang, who decided to explore it with other metals and landed on the idea of a sodium-based fuel cell.

In this fuel cell format, the device takes in chemicals and runs reactions that generate electricity, after which the products get removed. Then fresh fuel is put in to run the whole thing again—no electrical charging required. (You might recognize this concept from [hydrogen fuel cell vehicles](#), like the Toyota Mirai.)

Chiang and his colleagues set out to build a fuel cell that runs on liquid sodium, which could have a much higher energy density than existing commercial technologies, so it would be small and light enough to be used for things like regional airplanes or short-distance shipping.



Sodium metal could be used to power regional planes or short distance shipping.  
GRETCHEN ERTL/MITTR

The research team built small test cells to try out the concept and ran them to show that they could use the sodium-metal-based system to generate electricity. Since sodium becomes liquid at about 98 °C (208 °F), the cells operated at moderate temperatures of between 110 °C and 130 °C (or 230 °F and 266°F), which could be practical for use on planes or ships, Chiang says.

From their work with these experimental devices, the researchers estimated that the energy density was about 1,200 watt-hours per kilogram (Wh/kg). That's much higher than what commercial lithium-ion batteries can reach today (around 300 Wh/kg). Hydrogen fuel cells can achieve high energy density, but that requires the hydrogen to be stored at high pressures and often ultra-low temperatures.

“It's an interesting cell concept,” says Jürgen Janek, a professor at the Institute of Physical Chemistry at the University of Giessen in Germany, who was not involved in the research. There's been previous research on sodium-air batteries in the past, Janek says, but using this sort of chemistry in a fuel cell instead is new.

“One of the critical issues with this type of cell concept is the safety issue,” Janek says. Sodium metal reacts very strongly with water. (You may have seen videos where blocks of sodium metal get thrown into a lake, to dramatic effect). Asked about this issue, Chiang says the design of the cell ensures that water produced during reactions is continuously removed, so there's not enough around to fuel harmful reactions. The solid electrolyte, a ceramic material, also helps prevent reactions between water and sodium, Chiang adds.

Another question is what happens to one of the cell's products, sodium hydroxide. Commonly known as lye, it's an industrial chemical, used in products like liquid drain-cleaning solution. One of the researchers' suggestions is to dilute the product and release it into the atmosphere or ocean, where it would react with carbon dioxide, capturing it in a stable form and preventing it from contributing to global warming. There are groups pursuing field trials using this exact chemical for ocean-based carbon removal, [though some have been met with controversy](#). The researchers also laid out the potential for a closed system, where the chemical could be collected and sold as a by-product.

There are economic factors working in favor of sodium-based systems, though it would take some work to build up the necessary supply chains. Today, sodium metal isn't produced at very high volumes. However, it can be made from sodium chloride (table salt), which is incredibly cheap. And it was produced more abundantly in the past, since it was used in the process of making leaded gasoline. So there's a precedent for a larger supply chain, and it's possible that scaling up production of sodium metal would make it cheap enough to use in fuel cell systems, Chiang says.

Chiang has cofounded a company called Propel Aero to commercialize the research. The project received funding from ARPA-E's [Propel-1K program](#), which aims to develop new forms of high-power energy storage for aircraft, trains, and ships.

The next step is to continue research to improve the cells' performance and energy density, and to start designing small-scale systems. One potential early application is drones. "We'd like to make something fly within the next year," Chiang says.

"If people don't find it crazy, I'll be rather disappointed," Chiang says. "Because if an idea doesn't sound crazy at the beginning, it probably isn't as revolutionary as you think. Fortunately, most people think I'm crazy on this one."