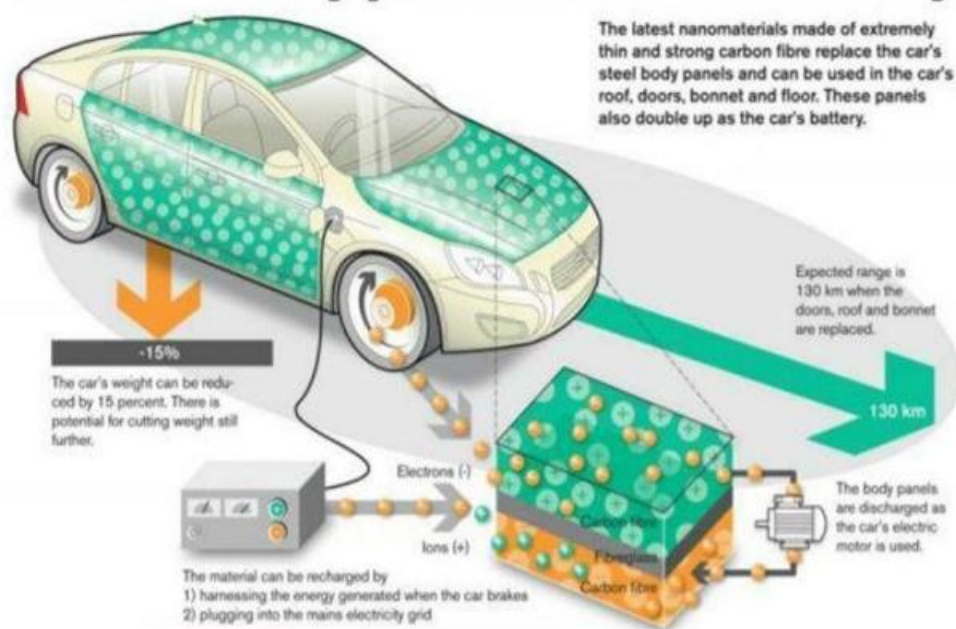


EV BATTERY PROGRESS VOL 2

Solid-state Battery Partnerships That You Must Know About

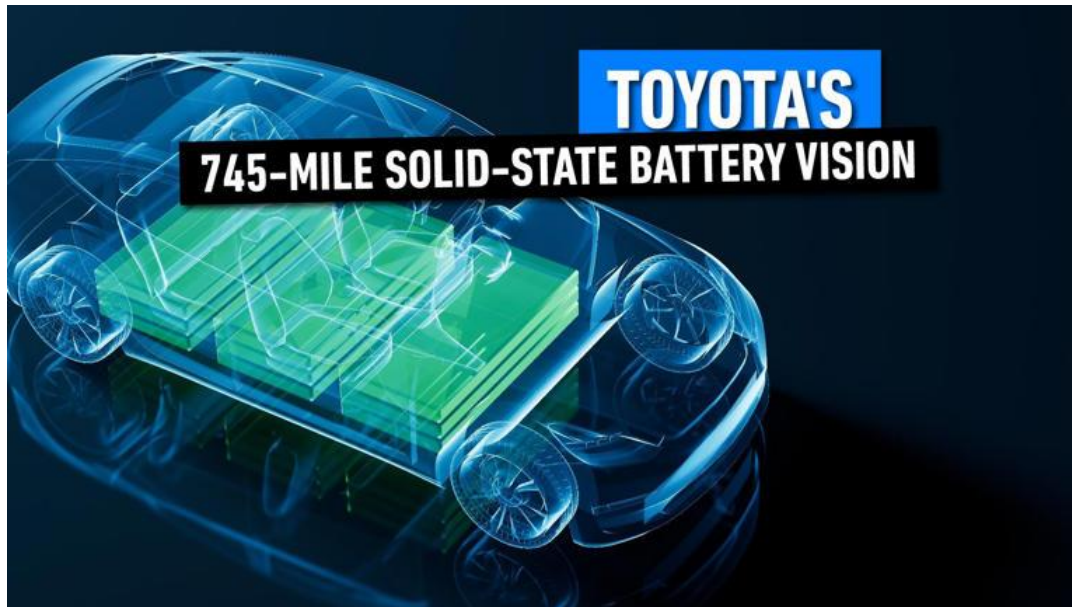
The car's body panels serve as a battery



When [Toyota](#) announced that it was developing mass-production technology for its [much-vaunted 745-mile solid-state battery](#) (SSB), it stood shoulder-to-shoulder with its technology partner Idemitsu. There are a number of such partnerships between carmakers and battery/technology firms working on SSBs, because although success will bring great rewards, perfecting this technology has proven to be challenging. Almost all major carmakers are racing to bring SSB EVs to market quickly, and most have realized that a technology partner will be vital to success.

SSBs are seen to be the answer to taking BEVs [beyond the limitations of the lithium-ion batteries](#) used for the past decade and a half. SSBs are cheaper to

make and can hold more energy, so an EV can be lighter and go longer on a single charge. Charging times will drop dramatically. They will last longer. SSBs are safer, as they can withstand more heat and the way they are made removes the fire risk inherent to lithium-ion batteries. Here is a list of such partnerships with an overview of what is involved and where they stand in the SSB race.



Toyota's-745-Mile-Solid-State-Battery-Vision

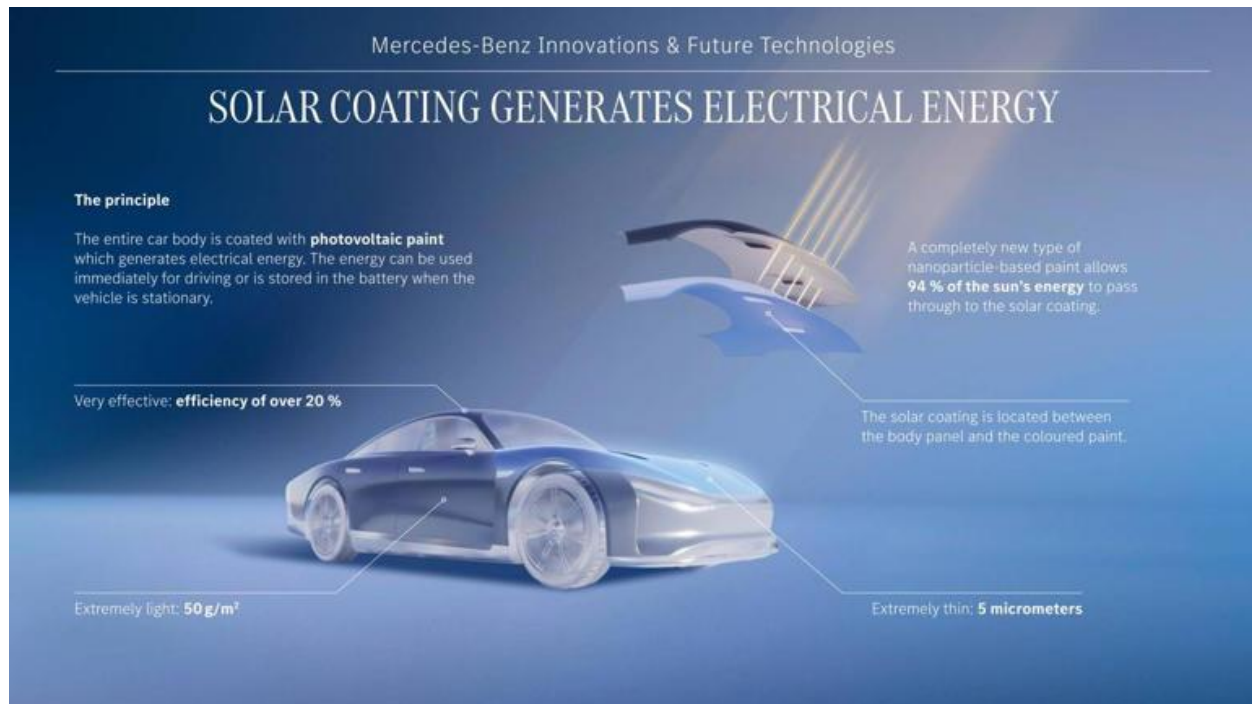
Toyota is making some serious strides in solid-state battery development, and its partnership with this oil giant has only strengthened the cause.

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, including automakers, battery makers, and other technology companies. This list is not a rank of biggest or best, but aims to show the most significant partnerships that will shape future EVs.

This "solar paint" continuously recharges electric cars ⚡

An electric car capable of driving without recharging, solely thanks to its exposure to the Sun: this dream could soon become a reality, provided the latest innovation from Mercedes-Benz delivers on its promises.

The German manufacturer has unveiled a groundbreaking technology: a solar paint incorporating photovoltaic nanoparticles. This thin layer, weighing just 0.1 pounds (50 grams) per square meter, can convert sunlight into electrical energy with an efficiency of 20%. Comparable to monocrystalline solar panels, it transforms the bodywork of vehicles into a renewable energy source.



This "solar paint" continuously recharges electric cars ⚡

Unlike traditional solar panels, which are often bulky and constrained by their orientation, this paint adapts to all shapes and angles of vehicles. As a result, the active surface area increases, allowing electricity to be generated on all parts exposed to sunlight.

The additional range announced for this innovation is impressive. In Los Angeles, a mid-sized SUV could travel up to 12,400 miles (20,000 kilometers) per year solely on solar energy. Even in less sunny regions, like Stuttgart, Mercedes estimates 7,500 miles (12,000 kilometers) of range, with about 60% of daily trips potentially covered by this technology.

This solution also promises significant environmental benefits. Unlike other energy technologies, this paint contains neither silicon nor rare earth elements, which are costly and challenging to extract. It is made from non-toxic and recyclable raw materials and aligns with a more sustainable approach.

In addition to its environmental impact, this paint could address a key challenge: insufficient charging infrastructure. In remote or poorly equipped areas, it would reduce dependence on charging stations while limiting the investments needed for their development.

However, several challenges remain. The efficiency strongly depends on weather conditions and sunlight. Furthermore, dirt or shadows can decrease the effectiveness of the photovoltaic cells. These limitations still require adjustments before large-scale commercialization.

Mercedes is also working on complementary innovations, such as onboard energy management systems. For example, a converter would regulate the energy produced, ensuring consistent voltage and optimizing bidirectional charging.

If this solar paint reaches its potential, it could transform the landscape of electric vehicles by offering increased autonomy, reduced costs, and a smaller ecological footprint. This is an innovation to watch closely, as it seems well-aligned with the objectives of sustainable mobility.

Toyota-Idemitsu



Toyota

Toyota and Idemitsu right now provide the clearest line of sight on what they will do and when it will reach the mass market. Toyota has a vision of reaching zero emissions, while Idemitsu, an oil company, started researching alternative energy in the '70s.

Idemitsu brings expertise in sulfide solid electrolytes, which bring softness and adhesion to other materials. This is essential to SSBs, both during manufacture and use. Toyota adds its expertise in anodes and cathode materials, battery production, manufacturing, and creating and marketing the vehicles in which these will be used.

Toyota Idemitsu SSB Timeline

- 2001 - Idemitsu starts working on sulfide electrodes.
- 2006 - Toyota starts working on SSBs.
- 2013 - The two companies form a partnership to develop a working SSB.
- 2021 - Toyota launched a tech demo model using SSBs.
- 2022 - 745-mile range SSB announced.
- 2024 - Toyota and Idemitsu mass production plans announced.
- 2027/2028 - Small to medium-scale production to start.
- 2030 - Full mass-production of a range of EVs using SSBs.

Nissan-NASA



Nissan

Nissan has been working solo on SSBs for years, but recently partnered with NASA to develop these batteries using cheaper and environmentally friendlier materials, replacing expensive cobalt and nickel with other materials. While NASA's interest in this technology is aimed at the needs of long-term space flight and BEV aircraft, Nissan's priority is to enter the mass EV market with competitive battery technology ahead of, or at least at the same time as, its competitors.

It recently opened a small-scale pilot plant to test the concept and develop mass-market production. Nissan is at the moment pursuing a two-battery strategy, one with a very long range, and a smaller one that can charge quickly, like filling the tank with gas. The partnership between Nissan and Nasa is limited to technology, and Nissan will develop SSB mass production on its own.

Nissan NASA Timelines

- 2010 - Nissan Leaf launched as the first affordable mass-market car.

- 2015 - Nissan and NASA create a partnership to develop autonomous vehicles.
- 2022 - Nissan and NASA start work on SSBs.
- 2024 - Nissan opens an SSB pilot plant.
- 2028 - Nissan intends to launch SSB EVs.

Volkswagen-QuantumScape



Volkswagen

[Volkswagen](#) was an early investor in tech startup QuantumScape. SSB innovations include anode-free architecture and a ceramic separator. PowerCO SE, VW's battery company, recently power-tested the QuantumScape SSB consisting of 24 layers, completing more than 1,000 charging cycles.

After the test, the battery had barely aged, [retaining 95 percent of its capacity](#). VW believes that its unified cell concept will work with this SSB. The next step would be to develop this technology to bring it to market.

VW QuantumScape Timeline

- 1972 - VW develops the Elektro-Bus in response to the oil crisis.
- 2010 - Tech startup QuantumScape is founded.
- 2011 - VW NILS concept to test Lithium-ion EVs.
- 2012 - VW starts working with QuantumScape.
- 2018 - VW invests \$100 million in QuantumScape specifically for SSB development.
- 2020 - QuantumScape goes public.
- 2024 - VW successfully tests QuantumScape battery performance.



Made-in-America Volkswagen ID.4© Provided by TopSpeed

Volkswagen and QuantumScape's solid-state battery was put through a preliminary test, and the results look promising.

BMW/Ford-Solid Power



Ford© Provided by TopSpeed

Solid Power is a U.S. tech company that focuses on developing SSBs with higher energy density, longer lifespan, and better safety. It has so far developed three different SSBs, all using sulfide solid electrodes.

Both [Ford](#) and [BMW](#) have invested in the company, and are currently testing [Solid Power batteries](#). While most manufacturers consider mass production of SSBs challenging, Solid Power believes its existing Lithium-ion production methods can be adapted to make SSBs at scale.

Solid Power, BMW, and Ford Timeline

- 2012 - Solid Power founded.
- 2017 - BMW partners with Solid Power to develop next-gen SSB technology.
- 2018 - Ford invests in Solid Power.

- 2019 - Ford and Solid Power announce SSB collaboration.
- 2020 - Solid Power delivers first SSB.

NIO-WeLion



Nio

NIO is a Chinese EV manufacturer, [selling vehicles globally](#), and listed on the NYSE. WeLion is a new energy company headquartered in Beijing. Its focus is research, development, and production of hybrid solid-liquid lithium-ion and all-solid-state batteries. It recently [started delivering 620-mile semi-solid batteries to NIO](#).

WeLion NIO Timeline

- 2016 WeLion is founded.
- 2018 WeLion's prototype SSB.

- 2021 WeLion and NIO form a strategic partnership to develop 1000km (620 miles) SSD.
- 2023 First SSB delivered to NIO.

Mercedes-Benz/Hyundai-Factorial



Mercedes

Factorial is another U.S.-based tech company leading the way in SSB development. It has patented a solid-state electrolyte material called FEST that allows safe and reliable cell performance with high voltage and capacity electrodes at room temperature.

The company claims its technology has 'drop-in' compatibility for easy integration with existing lithium-ion manufacturing infrastructure. Hyundai became Factorial's first major automotive investor in 2021, while Mercedes-Benz joined forces with Factorial later that same year. Factorial recently delivered the batch of B-sample batteries to Mercedes-Benz.

Factorial, Mercedes-Benz, Hyundai Timeline

- 2013 - Heritage Company is founded at Cornell University.
- 2019 - Factorial is spun off from the heritage company.
- 2018 - Factorial releases 10-layer Ah prototype.
- 2019 - 27 layer Ah prototype.
- 2023 - Unveiled SSB cell at CES.
- 2024 - Shipped B-samples to automotive partners.



2024 Honda Prologue Exterior© Provided by TopSpeed

Honda may only have one EV in production now, but it could be formidable competition in the very near future, courtesy of its strides with SSBs.

GM/Honda/Hyundai-SES AI



Honda

SES AI has signed development agreements with General Motors, Honda, and Hyundai. SES uses lithium metal as an anode to reduce weight, creating batteries with energy densities of up to 400Wh/kg and 1000Wh/kg, providing longer range to EVs, drones, and electric aircraft.

The company uses AI throughout the process, from research and development to cell design, engineering, manufacturing, and to manage battery health and monitor safety. SES AI has large factories in China and South Korea, and has built up solid supply chain networks to feed these factories.

SES AI, GM, Honda, and Hyundai Timeline

- 2012 - Founded as SolidEnergy Systems at MIT.
- 2013 - Took over the laboratory of the defunct A123 Partnership.
- 2016 - General Motors invests in SES AI.

- 2021 - Joint development agreements with General Motors, Hyundai, and Honda.
- 2025 - Commercial production of SSBs expected to start.

Stellantis-Factorial



Dodge© Provided by TopSpeed

Stellantis and Factorial have entered into a partnership to test SSBs in real-world conditions. [Stellantis will launch a demo fleet of Dodge Charger Daytona EVs](#) fitted with Factorial SSBs to assess and validate their performance on the road, over time.

The carmaker sees significant benefits in using this technology, including improved performance and lower vehicle costs. It has chosen its STLA Large multi-energy platform for later commercial production. STLA includes brands like Jeep, Dodge, Chrysler, Alfa Romeo, and Maserati.

Stellantis Factorial Timeline

- 2021 - Stellantis invests \$75 million in Factorial.
- 2026 - Stellantis to launch Dodge Charger Daytona SSB demo fleet.

BMW-Blue Solutions



BMW

Blue Solutions is a French company that started developing EV batteries in the early 2000s. Although it already manufactures large solid-state batteries for buses, it is now developing SSBs for cars.

These will use an LMP (lithium metal polymer) electrode and ultra-thin lithium metal anode, with a charging time of under 20 minutes and a range of over 620 miles. It has signed an agreement with BMW and is building a gigafactory in eastern France, close to both German and French automakers. Production is due to start in 2030.

BMW Blue Solutions Timeline

- 2003 - Blue Solutions started SSB research.
- 2007 - Blue Solutions started producing large SSBs for buses.
- 2023 - BMW and Blue Solutions sign a deal to develop and make SSBs BMW EVs.
- 2024 - Blue Solutions starts building its French gigafactory.
- 2029/30 - Delivery of SSBs to BMW to commence.



Mercedes-Benz Concept CLA-Class

Mercedes could be selling battery-electric cars with ranges of over 600 miles by the end of the decade, thanks to a new solid-state battery.

Mercedes-Benz/Stellantis-Total Energy/Prologium



A front rendering of the Mercedes-Benz Vision One Eleven Concept, its motors and battery pack© Provided by TopSpeed

This SSB partnership is called the Battery Cell Company (BCC) and differs from the others discussed above, in that it was founded in 2020 to build a Europe-wide EV presence. The founding partners were Stellantis and Total Energy, with support from the German and French governments, and the European Union.

Mercedes-Benz joined soon after, followed by Taiwanese SSB giant Prologium. It has research facilities in France and Taiwan, as well as factories, built or planned, in France, Italy, and Germany. Prologium is currently the only energy company that mass produces SSBs, with factories in Taiwan and one being built in Dunkirk, France.

Timelines

- 2006 - Prologium is founded.
- 2020 - Battery Cell Company is created with partners Stellantis and Total Energy.

- 2021 - Mercedes-Benz joins BCC.
- 2022 - Prologium joins BCC.
- 2023 - Construction of gigafactory in Hauts-de-France starts, expected to finish in 2024.
- 2030 - Aimed production of two million batteries per year.

This Japanese Automaker Is Becoming A Threat To China With Its Solid-state Battery Development

The most frustrating part of [EV design is the battery](#). They are annoyingly bulky, don't offer the same range as a full tank of gasoline, and often weigh more than the engines they replace. Automakers have been aching to reclaim the lost interior space and weight capacity ever since [electric vehicles](#) finally went mainstream. As a result, the auto industry has put a lot of money and optimism into solid-state batteries, which (if one listens to the press releases) would get twice the range out of a battery half the size.

China has emerged as a world leader in EV development, which is a natural result of being the world's biggest EV market. But, this automaker from Japan is threatening to take China's spot at the top of the electrified world.

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.

From an initial 932-mile range to a still-incredible 745 miles of juice, here's the real story behind Toyota's impressive solid-state battery.

Toyota Could Be The Future Leader Of EVs



Toyota prototype solid-state EV battery stack on display© Provided by TopSpeed

- Toyota's lackluster history with EVs makes it easy to doubt that it will be a serious contender in the future.
- Toyota has been developing new EV technology behind the scenes.

It's easy to be skeptical of Toyota's EVs. For years, it has looked like the company was hoping that electric cars were an inconvenient fad that would soon go away. Perhaps in a tacit acknowledgment that its EV offerings are a bit scanty, Toyota prefers to use the lookalike term electrified vehicle as a catch-all for its hybrids, hydrogen cars, and its lone BEV. However, away from public view, Toyota has been developing EV technology that could outpace it ahead of everyone else.

Toyota's Extensive Research Prepares It For The Solid-State Future

Away from public view, Toyota has a long history of solid-state battery development. The automaker shares over 1,000 battery-related patents with fellow Japanese company Panasonic. Additionally, [it has been in a partnership](#)

with petroleum company Idemitsu since 2023. While such an alliance may seem more appropriate for developing something related to gasoline, Toyota is using petroleum byproducts to synthesize its solid electrolytes.

Indeed, it looks like Toyotas battery development is getting closer to paying off. The company has often claimed a hypothetical battery range of 745 miles. But it recently raised that number to 932 miles on a single charge.

Toyota's Hit-Or-Miss History With EVs

While its all-electric version of the RAV4 seemed like a promising early stake in the EV market when first offered in 2012, Toyota discontinued it two years later. The company completely avoided the market for EVs, instead focusing on its lucrative hybrids and occasionally quixotic hydrogen cars. Toyota wouldnt attempt another EV until it launched the bZ4X in 2022. Even then, Toyota didnt reenter the EV market with a daring design. Instead, the bZ4X is a competent and thoroughly inoffensive family SUV.

It must also be admitted that Toyota has been working on solid-state batteries for well over a decade with little to show for it. However, this can be attributed to the companys famous reliability. Toyota has always been careful to live up to its reputation for making indestructible vehicles. (As the joke goes, the only survivors of a nuclear apocalypse would be the cockroaches and someones dented Corolla.) It therefore follows that Toyota would not sell any technology it had not thoroughly tested. While other companies may use their customers as unwitting beta testers, Toyota does not.

Where Is China's EV Industry Now?

- China is currently home to the biggest EV market in the world.
- The biggest companies in China's EV industry, together with members of the Chinese government, have formed a consortium called CASIP to develop solid-state batteries.

- CASIP member Nio already has EVs with semi-solid state batteries available for lease.

China has become the worlds biggest EV market. Indeed, so many EV manufacturers have emerged to meet demand that there have been [worried rumblings about overcrowding](#). But business is booming on EV sales lots, regardless of whether various companies management can withstand the next few years. A lot of Chinese EV manufacturers have taken the gush of profits and invested them in technological R&D, which is already paying off.

CASIP: The Brains Behind China's Solid-State Batteries

In early 2024, some of the largest players in Chinas EV industry united to form the [China All-Solid-State Battery Collaborative Innovation Platform](#) (CASIP for short). This consortium also includes various relevant ministries of the Chinese government. Some CASIP members that US-based automotive enthusiasts may have heard of include battery manufacturer CATL (Teslas former supplier) and BYD (currently the [biggest EV producer in the world](#)). In other words, CASIP unites a lot of brains and a lot of money.

Semi-Solid State Batteries: The Chinese EV Industry's Success

CASIP member Nio has already had success with semi-solid state batteries. (For those who have never heard the term, a semi-solid state battery stores its energy in a mixture of solid and liquid electrolytes.) The company famously installed one into one of its cars and live-streamed a 648-mile drive on a single charge with the CEO personally taking the wheel.

Less than a year later, [Nio has begun public trials of semi-solid state batteries](#). As is often the case with radically new vehicles (such as the Chrysler Turbine and the

GM EV1), Nio is leasing rather than selling them. For the time being, semi-solid state Nios are only available on a daily lease rather than a long-term one. Nevertheless, this is the first time a semi-solid state battery has been made available to the public.

Toyota's Long History Of Reliability

- Toyota has a long-earned reputation for some of the most reliable cars money can buy.
- Because Toyotas are known for their durability, Toyota can introduce new technologies that customers wouldn't necessarily trust from other automakers.
- Toyota's reputation for dependable cars has resulted in high sales volume, giving the company the financial means to thoroughly test its solid-state batteries.

Toyotas biggest asset is its long and ongoing history of making indestructible cars. Used Toyotas command some of the highest prices on dealer lots because people know their newly purchased cars will spend more time on the road than on a mechanics lift. Such unfailing dependability only comes from careful design and testing, which is why Toyotas technological development can seem maddeningly slow at times. But although Toyotas arent loaded with bleeding-edge gimmickry, they arent beset with failures either. This has allowed Toyota to introduce new technologies the driving public would not trust from any other manufacturer.

Toyota Has A Long History Of Understated Innovation

Automotive connoisseurs often dismiss Toyotas lineup as appliance cars, and primarily respect them for the fact that they routinely reach odometer readings

that other automakers can only dream of. However, Toyota has a long history of innovation. Perhaps most notably, Toyota introduced the world to hybrid cars. Although Toyota didn't invent hybrids, it was the first company to get people to actually buy them. To this day, the Prius is the de-facto standard-bearer for hybrid vehicles in general. (Indeed, the Wikipedia page for hybrid vehicles uses a Prius as its top illustration.)

More recently, Toyota has near-singlehandedly launched the market for hydrogen cars. Of course, it's easy to scoff that hydrogen cars will never take off despite Toyota's [sometimes quixotic determination to make them catch on](#). But until the first freightloads of Priuses reached dealer lots, hybrid cars seemed like a wacky idea too.

Toyota Can Afford To Get SSBs Perfect Instead Of Good Enough



Ford© Provided by TopSpeed

It should surprise no one that [Toyota is the top seller in the world by volume](#) as of 2023. This gives Toyota an ample financial cushion to perfect its products

rather than rushing something into production before the money runs out. Toyota is taking full advantage of this in its solid-state battery development.

Optimism in Toyotas solid-state batteries has eroded over the years, and Toyota certainly hasn't helped matters by its near-total secrecy on the project. However, it looks like the years and patents will finally pay off. The company is building a solid-state battery factory in North Carolina which (if things remain on schedule) will be online by 2027 or 2028.

The biggest takeaway from building a factory is that Toyota has apparently figured out how to mass-produce solid-state batteries instead of making a few laboratory one-offs. Scaling up SSB production has been a fiendishly difficult problem. It's nowhere near as straightforward as doubling or tripling a recipe.

Toyota confirms plans to introduce solid-state batteries as soon as 2027 with up to 745 miles of range.

The Frustrating Road To Solid-State Batteries

At times, the pursuit of solid-state batteries can seem like a bigger folly than fully self-driving cars. Because of their inherent properties, the chemistry of solid-state batteries has only worked in very small devices like hearing aids. As soon as anyone tries to make an SSB large enough to power an entire car, a lot of pesky physics problems get in the way.

Even after figuring out how to produce a viable car-sized SSB, any company aspiring to be the next battery pioneer has to figure out how to crank them out in mass production. Some processes are easy to scale up, but battery production is not one of them.

SSBs Could Convince More People To "Make The switch" To EVs

If solid-state batteries do take off, they could finally convince a lot of EV skeptics to adopt one. Polls show that the [biggest objections to EVs are range and charging time](#). Solid-state batteries tend to take fast-charging a lot better than normal EV batteries do. (Sending a surge of electricity into batteries wears them down faster than trickle charging.) And, of course, every company announcement about SSBs, regardless of who is putting it out, gives a range estimate that surpasses any ICE vehicle with a full tank of gas. Additionally, solid-state batteries would theoretically last a lot longer than other battery types. Early testing [suggests that they could easily last](#) for the full lifetime of a car.

Toyota Would Never Put Out Half-Tested Technology

An abstract concept like "corporate reputation" cannot be reduced to a number and entered into a spreadsheet. Nevertheless, Toyotas long and ongoing history of bulletproof cars is arguably its biggest asset. Toyota may be the reason the advice to get a Japanese car is practically a cliché.

With that in mind, Toyota is not about to risk losing its customers by rushing a half-tested technology to production. However, as its projected production date nears, Toyota could seize the solid-state market just like it took over hybrids before anyone else got a chance.

The Real Story Behind Toyota's 745-Mile Solid-State Battery

[Toyota](#) is pushing the boundaries of electric vehicle (EV) technology with its [development of a potentially game-changing 745-mile solid-state battery](#). As one of the most significant advancements in electric powertrains, this new battery technology promises to help reshape the market by providing longer ranges and faster charging times. Toyota's innovation has been generating considerable hype alongside [Samsung's 600-mile battery of its own](#), marking a potential turning point in the race to make EVs more practical and accessible for everyday consumers.

Solid-state batteries are widely considered the next big step in battery technology, [offering several advantages over traditional lithium-ion batteries](#). With the ability to store more energy in a smaller space, these batteries could drastically improve the driving range of EVs, helping to improve reliability and reduce range anxiety. That said, the technology as a whole is not without its own obstacles, and Toyota has faced its fair share, with this very battery originally being slated as having a 900-plus-mile range before getting lowered to its current estimate.

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, including Toyota and Samsung.

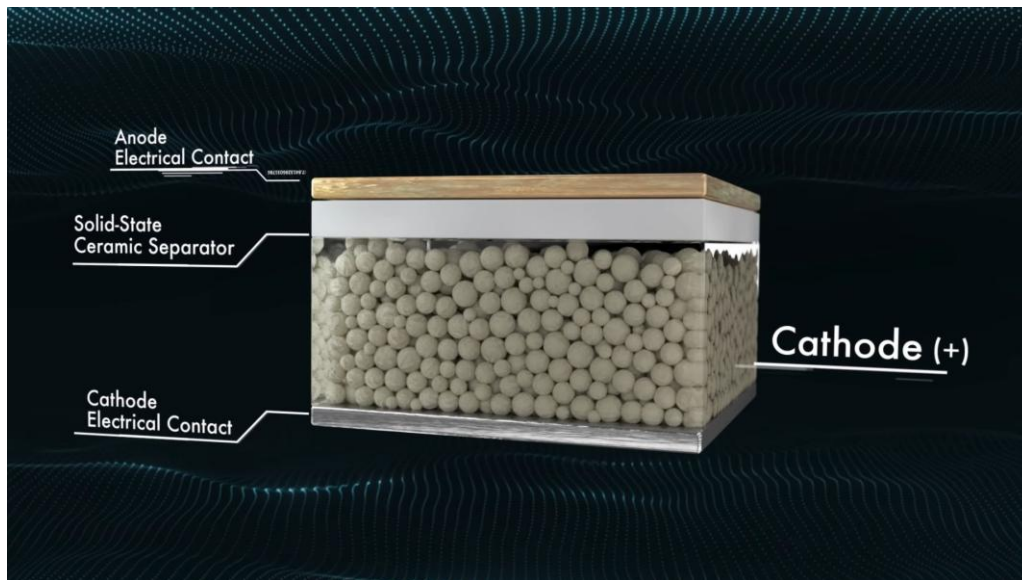
Toyota's 745-Mile Battery Could Be A New Milestone For EVs

Major Breakthroughs In Battery Technology

Solid-state battery technology, including that from Toyota, represents a significant leap over conventional lithium-ion batteries. Traditional batteries use liquid electrolytes, which can limit energy density and pose safety risks such as overheating and fires. In contrast, solid-state batteries replace the liquid electrolyte with a solid material, allowing for higher energy density, faster charging times, and reduced safety concerns. These advancements mean that more energy can be stored in a smaller, lighter battery, making them even more efficient than they are now.

Beyond the improvements in energy storage, solid-state batteries also address charging speeds, one of the biggest barriers to EV adoption. Toyota's new battery is expected to cut charging times significantly, bringing the time to fully charge a battery down to ten minutes or less. This could eliminate one of the biggest drawbacks of EVs today, helping them [take an even bigger slice of the automotive market share](#) from regular gasoline-powered vehicles.

The Impact Of 745 Miles Of Range On The EV Market



QuantumScape

via YouTube

With 745 miles of range on a single charge, Toyota's solid-state battery could help change the landscape and overall adoption of EVs. Currently, most [EVs offer a range between 200 and 400 miles](#), though [some like the Lucid Air Grand Touring stand out](#) with 516 miles of range, which is sufficient for daily driving but still lags behind the convenience of gasoline-powered cars. A 745-mile battery would not only close this gap but also exceed the range of almost all traditional internal combustion engine (ICE) vehicles, effectively putting an end to concerns about long-distance travel in an EV.

Such a dramatic increase in range could also shift consumer perceptions of EVs, potentially speeding up their adoption. Range anxiety has been a [long-standing hurdle for potential buyers](#), but a vehicle from Toyota that can drive for nearly 750 miles without needing to recharge would make EV ownership much more appealing. By combining Toyota's legendary reliability with a long-lasting battery, this new tech could help push more buyers over the line into EV ownership.

How Toyota's Solid-State Battery Technology Works

Solid-State Batteries vs. Traditional Lithium-Ion

The key difference between solid-state batteries and traditional lithium-ion batteries lies in the electrolyte. While lithium-ion batteries use a liquid electrolyte to transport ions between the anode and cathode, [solid-state batteries replace this liquid with a solid electrolyte](#). This shift results in several advantages, most notably the ability to store more energy in a smaller space, which allows for higher energy density, and they also eliminate the risk of leakage and overheating, improving safety. Additionally, solid-state batteries are known for their potentially longer lifespans and faster charging times compared to their liquid counterparts.

Key Features Of Toyota's Solid-State Battery

The obvious answer here as to one of the key features of Toyota's new battery is its ability to deliver a driving range of 745 miles. But we can do better than just that. Additionally, this battery promises faster charging times, with the potential to fully recharge (up to 80 percent capacity) in as little as ten minutes. It's also projected to last for more than 1,000 charging cycles and provide up to 500,000 miles of life before failure. This puts current batteries to shame, even with Tesla's impressive performance and [lack of significant degradation over 200,000 miles](#).

Toyota's progress in solid-state battery development has also gained recognition from the Japanese government. Toyota recently announced that its next-generation batteries, including its all-solid-state batteries, [have been certified by the Ministry of Economy, Trade and Industry](#) (METI) as part of Japan's Supply Assurance Plan for Batteries. This certification covers the production and research efforts of these batteries at Toyota's partners, and production scale is expected to reach nine gigawatt hours (GWh) per year, starting from 2026.

Toyota's 745-mile solid-state battery promises to be amazing, but it's not the only one invested in SSBs. Here's how the industry is catching up.

Challenges And Obstacles Toyota Must Overcome

The Rumored 900-Mile Battery And What Changed

When Toyota's solid-state battery development first started getting hyped up, early [reports hinted at an astounding 932-mile range](#). This initial figure sparked excitement, as it promised to obliterate existing range limitations for electric vehicles. However, as development

progressed, Toyota has lowered expectations a bit, settling on a still-impressive 745-mile range.

While the shift from a rumored 900-mile range to 745 miles may seem like a step back, it is important to note that even this updated range still places Toyota well ahead of most competitors in the EV market, far outdoing what any standard lithium-ion battery can do while leading the way among solid-state battery manufacturers. The focus now is on making this breakthrough technology practical, scalable, and cost-effective for widespread use.

High Production Costs And Scalability Issues

One of the most significant obstacles facing Toyota's solid-state battery technology is the high cost of production, similar to one of the [main hurdles facing hydrogen cars](#). Solid-state batteries require complex materials and manufacturing processes that are not yet optimized for mass production. Currently, the cost of producing these batteries is much higher than traditional lithium-ion batteries, making them less accessible to everyday consumers and likely only practical for high-end EVs with an already sky-high starting price. Scaling production to meet global demand will require significant investment and innovation in manufacturing techniques to drive costs down.

In addition to cost, scalability remains a challenge. Toyota is working to ramp up production, with plans to implement its next-generation batteries in stages, starting in 2026 with a goal of producing 9GWh annually as noted above, following the METI certification. However, reaching the scale necessary to make solid-state batteries viable for mainstream EV production will take time and cooperation across the industry. While Toyota is actively taking steps to overcome these issues, scalability will be tough, and with other emerging technologies being worked on simultaneously, it'll be interesting to see how this plays out.

The Future Of Toyota's Solid-State Battery Technology

Upcoming Innovations In EV Technology From Toyota

In addition to its solid-state battery efforts, Toyota is doubling down on hydrogen fuel cell technology as part of its long-term strategy. The Japanese automaker has been a leader

in [hydrogen-powered vehicles](#), with its [Mirai](#) model being the best-selling hydrogen car in the world. Toyota seems to view hydrogen fuel cells and solid-state batteries as complementary technologies, both contributing to its goal of achieving carbon neutrality.

Consumer Adoption And How It Compares To Samsung's 600-Mile Battery

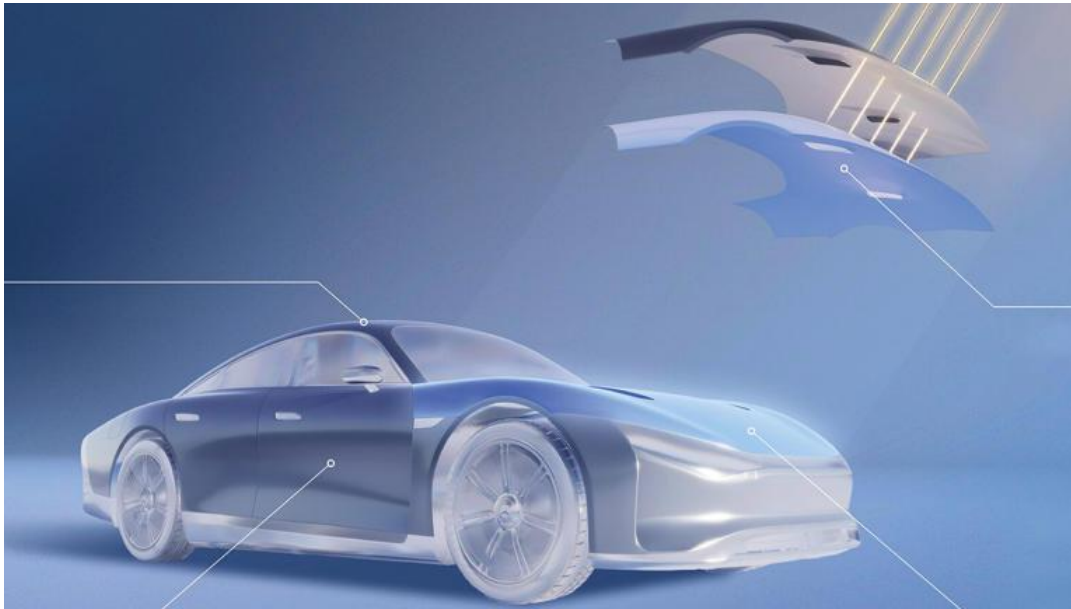
While Toyota's 745-mile solid-state battery is groundbreaking, it faces stiff competition from other key players like Samsung, which recently [unveiled its 600-mile solid-state battery](#).

Although Samsung's battery falls short in terms of range, it still boasts impressive energy efficiency and fast charging capabilities, making it a formidable competitor in the EV market. Plus, it's already hit the market and is actively being tested in real-world applications as we speak.

Consumer adoption of solid-state batteries and other emerging energy sources will hinge on a combination of factors, including price, availability, and real-world performance. Toyota's established presence in the automotive industry gives it an advantage in terms of trust and market reach, which could help accelerate consumer acceptance. As more drivers become aware of the benefits of solid-state technology, ranging from longer ranges to faster charging times, the market for these batteries is expected to grow rapidly, and we'll be here at the forefront of innovation to watch it all go down.

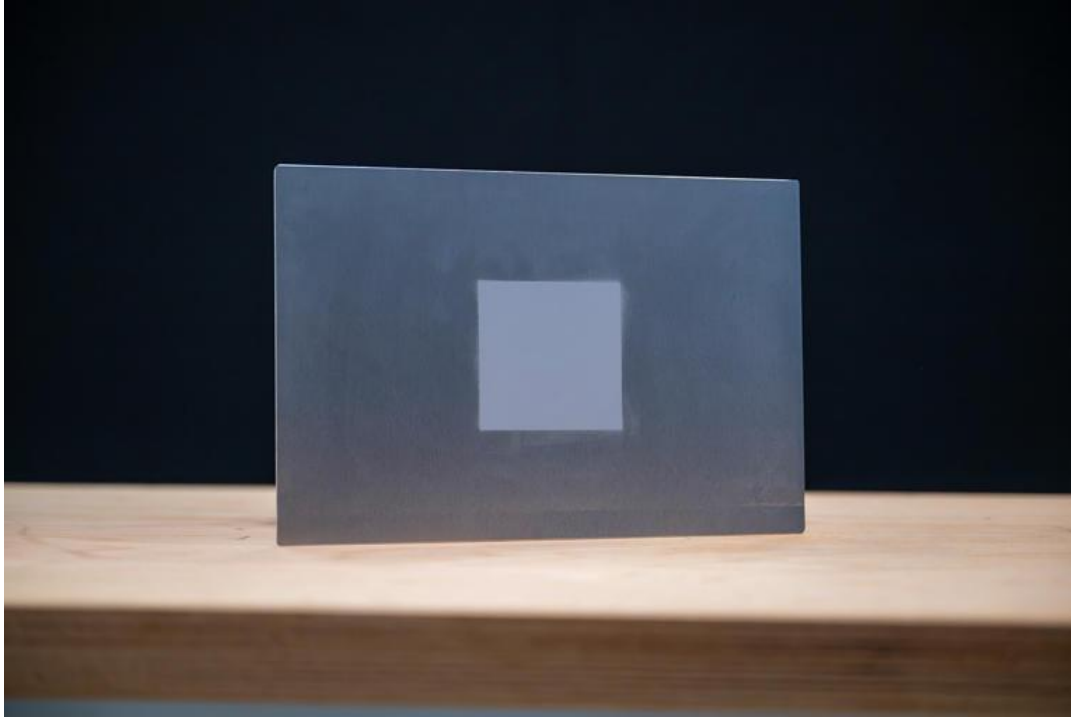
Mercedes' Solar Paint Could Make Plugging In EVs a Thing of the Past

A photovoltaic paste under development could turn ordinary body panels into solar panels.



Mercedes' Solar Paint Could Make Plugging In EVs a Thing of the Past

It sounds like an idea straight out of a five-year-old's imagination: A car covered in solar panels runs entirely on energy from the sun. As far-fetched as it seems, this isn't pure fantasy. [Mercedes-Benz](#) says it's developing a solar paint that would allow [electric vehicle](#) owners in places like Los Angeles to power their daily driving without ever plugging in.



Mercedes Benz solar paint tech demo 1 © Eric Tingwall, Manufacturer

The German automaker teased the idea last week during a future technology showcase at its R&D center in Sindelfingen, Germany. The photovoltaic material starts as a paste and is applied to body panels in a layer that's just 5 micrometers thick—thinner than a human hair. Covering every body panel of a mid-size SUV with the material would create 118 square feet of sun-harnessing surface area, a more than three-fold increase compared to the 32 square feet available from a single flexible panel on the roof.

SOLAR COATING GENERATES ELECTRICAL ENERGY

The principle

The entire car body is coated with **photovoltaic paint** which generates electrical energy. The energy can be used immediately for driving or is stored in the battery when the vehicle is stationary.

A completely new type of nanoparticle-based paint allows **94 % of the sun's energy** to pass through to the solar coating.

Very effective: **efficiency of over 20 %**

The solar coating is located between the body panel and the coloured paint.

Extremely light: **50 g/m²**

Extremely thin: **5 micrometers**

Mercedes Benz solar paint tech demo 3 © Eric Tingwall, Manufacturer

Mercedes claims such a vehicle could capture enough energy to drive about 12,500 miles a year in sun-soaked Los Angeles. A cloudier city such as Stuttgart, Germany, sees enough sunshine to provide 7,500 miles a year. Mercedes isn't saying exactly what the photovoltaic paste is made of other than that it contains no rare earths, no silicon, and relies on readily available, non-toxic raw materials.

MORE RANGE WITH SOLAR COATING

Stuttgart:
around 12,000 km/year*

Beijing:
around 14,000 km/year*

Los Angeles:
around 20,000 km/year*

The potential range achieved depends on the actual solar radiation

*Calculation based on average solar radiation and the surface area of a mid-size SUV

Each body panel needs to be galvanically isolated and wired into a power converter that sends the electricity to the battery or directly to the motors. The solar material is topped with a nanoparticle-based paint that allows 94 percent of the sun's energy to reach the photovoltaic coating while offering a full spectrum of color choice. Darker colors capture more energy than lighter hues, with the coated body panels achieving up to 20 percent efficiency in turning sunlight into electricity. That's on par with today's commercially available solar panels.

As an advanced research project, it's too soon to know if this solar paint will make it to production, but the fact that Mercedes is talking about it publicly means there's some substance behind the concept. Here's to hoping the future includes cars fueled by free energy.

Honda has a plan to build solid-state batteries for EVs



Honda has a plan to build solid-state batteries for EVs© Image: Honda

Honda set up a demonstration facility in Japan to show off its plans to mass-produce solid-state batteries at lower costs, which could be crucial to unlocking higher-range, longer-lasting electric vehicles for the future.

Solid-state batteries have been elusive for many companies due to the complexity of scaling up production. The technology swaps out the liquid electrolytes found in current lithium-ion batteries with dry conductive materials, promising higher energy density and longer lifespans. But it will require a whole new production process to be successful.

Several companies are actively pursuing solid-state batteries, including Volkswagen-backed [QuantumScape](#), [Nissan](#), and Factorial, which is testing [semi-solid-state batteries that fit Dodge Chargers](#).



Roll pressing of cathode for solid-state batteries. © Image: Honda

Honda says it is accelerating research at its new 27,000 square-meter demo facility set up in Sakura City, Japan, and is shortening the time required to make a

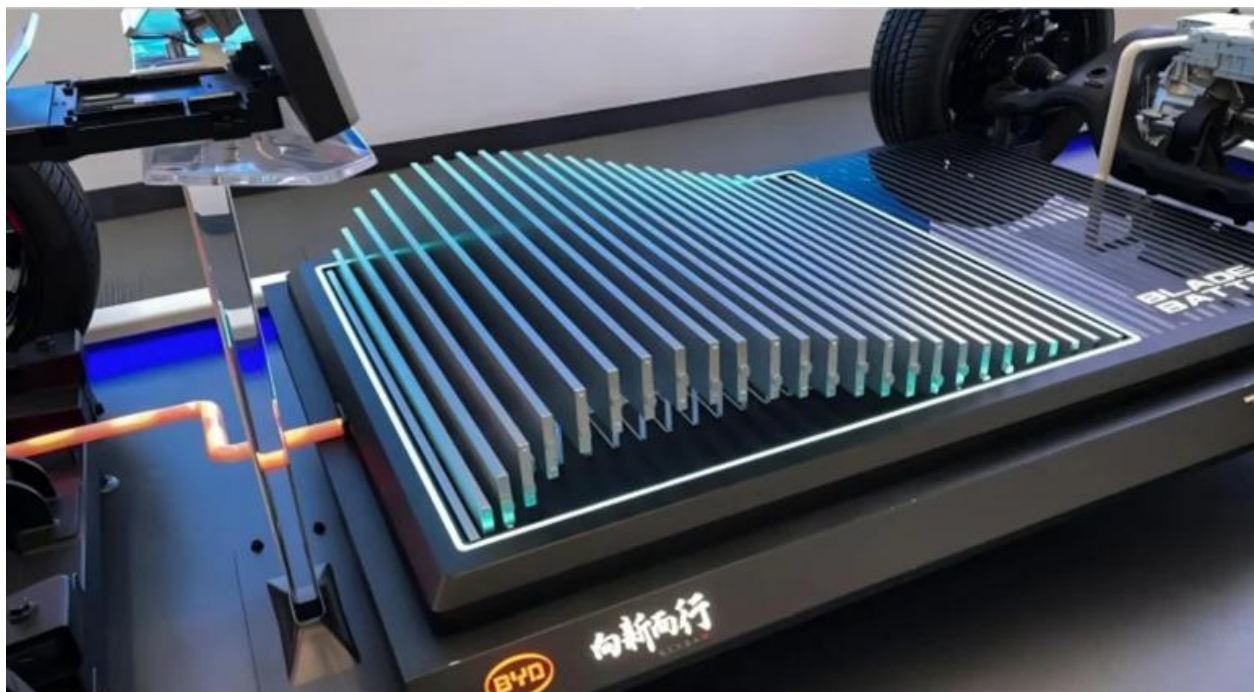
single unit. The site has full-scale equipment that is split between three buildings: the first for cathode formation and cell assembly; the second for anode formation; and the third for electrolyte activation and module assembly.

The plan includes using a continuous inline mixer that Honda says is “three times faster” than typical cell batch processing. Honda plans to make batteries on this line in January.

Honda is readying its solid-state tech for mass production in the second half of the 2020s. The company’s CEO Toshihiro Mibe has eluded that solid-state batteries will also be the [key to unlocking cheaper EVs](#).

Meanwhile, Honda is leaning on its other efforts to stay on top of the EV game. Honda’s [Prologue SUV](#), built on GM’s EV platform, is [doing pretty well](#) in the US, and the company is [readying a larger SUV for 2025](#). It’s also introducing a production vehicle at CES that will use the new [Honda Zero platform](#), which is powered by LG batteries (Honda and LG are [building a battery plant together in Ohio](#)).

BYD’s next-gen Blade battery for safer, more powerful EVs to launch in 2025



BYD's next-gen Blade battery for safer, more powerful EVs to launch in 2025

China's electric vehicle manufacturer BYD has announced its intentions to release its new Blade battery design in 2025.

The same was revealed by Cao Shuang, General Manager of BYD's Automotive Sales Division for Central Asia, at the 29th United Nations Climate Change Conference (COP29).

Shuang revealed that the company is planning to release the next generation of Blade batteries for EVs in 2025, as per him the new model is expected to offer an extended lifespan, alongside enhancing the driving range of the EVs.

It is expected that the second-generation Blade battery will build on the less bulky first model lithium-iron-phosphate battery the company had launched in 2020.

The first model Blade battery had reportedly been considered safer, and non-flammable as compared to the other offerings in the market for powering EVs.

What makes BYD's Blade batteries better?

BYD [states](#) that its Blade battery uses Lithium Iron Phosphate (LFP), which has undergone testing through the nail penetration method.

In the nail penetration test, a nail is driven through the center of the battery cell until it penetrates to the other side, causing a short circuit inside the battery cell.

BYD had [earlier reported](#) that its Blade battery had demonstrated higher safety standards in the test as compared to Lithium Nickel Manganese Cobalt Oxide and Lithium Nickel Cobalt Aluminum Oxide batteries.

Its design resembles that of a blade, making it thinner and longer than conventional batteries. This design enables Blade batteries to dissipate heat more quickly than typical rectangular cell batteries.

In the event of a short circuit within a cell, it does not affect other cells, thus preventing continuous electrical short circuits, as per the company.

One of the biggest advantages of the Blade battery is that it is designed using cell-to-pack technology (CTP). It means each cell can be directly packed without the need for module packing, allowing for more cells to be added.

Furthermore, it can also enhance the structural strength of the EVs by serving as a reinforcement material for their frames.

Additional benefits

The company also states that the Blade batteries have lower production costs compared to NMC (Lithium Nickel Manganese Cobalt Oxide) battery.

Its decomposition temperature is around 518 degree Fahrenheit (270 degree Celsius) as compared to the NMC's 410 degree Fahrenheit (210 degree Celsius) and NCA's 302 degree Fahrenheit (150 degree Celsius).

The higher decomposition temperature makes it safer for use. Moreover, once damaged the LFP Blade battery releases less heat – approximately 200 J/g, whereas NMC and NCA batteries can release up to 600 and 900 J/g of heat, respectively.

A report by South Korean publication [Korea JoongAng Daily](#) mentions that BYD is pitching Blade [batteries](#) as a viable alternative for powering EVs in the Asian country.

The report states the [Chinese](#) manufacturer is presenting it as a safe option to help curtail the fear in the minds of the consumers which resulted from a number of EV battery fires reported in the country.

The company is planning its official debut in the Korean market in January 2025.

FORMULA E 2025, THE LATEST GENERATION CAR

GEN3 Evo

Formula E and the Fédération Internationale de l'Automobile (FIA) have today revealed the next generation of race car, the new all-electric **GEN3 Evo**, capable of 0-60mph in 1.82s.

The new-look Formula E car for the next two seasons, to be known as the **Gen3 Evo**, will boast “acceleration 30% faster than a current Formula 1 car, and 36% faster than the current Gen3” according to the series.

FORMULA E AND FIA UNVEIL GEN3 EVO RACE CAR CAPABLE OF 0-60MPH IN JUST 1.82S

- Latest GEN3 Evo becomes the current fastest accelerating FIA single seater on the planet, designed for world-class racing on any track.
- New innovative features include all-wheel drive at critical points in the race; an aggressive, more robust and aerodynamic body kit for closer racing; and upgraded Hankook iON race tyres with enhanced grip, made from 35% recycled and sustainable materials.
- With significant enhancements over its predecessor, the GEN3 Evo remains the most efficient, sustainable and powerful electric race car in the world, capable of 200mph.

Formula E and the Fédération Internationale de l'Automobile (FIA) have today revealed the next generation of race car, the new all-electric GEN3 Evo, capable of 0-60mph in 1.82s.

Leveraging a roster of innovative technical upgrades, the GEN3 Evo unveiled at H.S.H Prince Albert II's Private Car Collection will debut in Season 11 of the ABB FIA Formula E World Championship where some of the world's greatest manufacturers and drivers race wheel-to-wheel in iconic locations around the globe.

Developed by specialists from Formula E and the FIA, the latest GEN3 Evo edition marks a significant leap in electric racing technology. Capable of accelerating nearly a full second faster than its predecessor – the GEN3 – that was the world's first race car designed for street racing, it sets an even higher standard in performance, sustainability, and efficiency. The GEN3 Evo serves as a formidable ambassador for the future of motorsport, embodying cutting-edge advancements and a commitment to environmental responsibility.

Key technical enhancements for the new GEN3 Evo race car include:

- The current quickest accelerating FIA single-seater race car – Capable of 0-60mph in 1.82 seconds (0-100kph in 1.86s).

- Faster, stronger, more agile – Performance upgrades providing an estimated 2% performance gain from GEN3, equating to a c.2 secs faster qualifying lap on the Monaco circuit, offering world-class racing on any track.
- Leaner and meaner – An aggressive new body kit designed to be stronger, more robust and more aerodynamic, delivering closer wheel-to-wheel racing.
- All-wheel drive (AWD) –A first for a Formula E car, available during qualifying duels, race starts, and ATTACK MODE. This feature maximizes acceleration and control, elevating the thrill of critical race moments and intensifying driver rivalries. AWD enhances both performance and strategy, providing more exciting racing for drivers and fans alike.
- Better grip – Optimised all-weather Hankook iON tires providing 5-10% more grip, made from 35% recycled and sustainable materials (+9% vs GEN3 spec).

These new additions are specifically designed for faster and closer racing between drivers, giving fans even more on track action and building on the world-leading specification of the GEN3 car, including:

- The fastest Formula E car: Top speed of 200mph
- Regenerative braking: Cars optimise the 600kw regenerative braking capacity to generate nearly 50% of the energy needed for a race, during the race itself.
- Enhanced performance by software: Race performance upgrades made through software engineering.
- Most efficient formula car ever: An electric motor with over 90% efficiency, significantly surpassing the 40% efficiency typical of internal combustion engines.
- Minimising production footprint: The world's first net zero carbon race car in the world's first net zero carbon sport.
- Sustainable battery development: Suppliers of battery cell minerals selected on ethical and sustainable mining standards to ensure a positive or neutral impact on people and the planet.
- Lifecycle thinking: Life cycle thinking throughout the car's construction; second life and recycling for battery cells; recycled carbon fibre and natural materials such as linen integrated into the chassis.
- Conscientious supply chain: All suppliers held to strict sustainability KPIs, achieving FIA 3* Environmental Accreditation certification by Season 9.
- Race-to-road transfer: Specific road-relevant areas of the car are opened for development by teams and manufacturers, designed for direct tech transfer to automotive industry.
- Ultra-fast charging capability: A new technological development still in development, designed to allow a 30sec 600kw high-speed charge for additional energy mid-race.

As part of the technical roadmap of the ABB FIA Formula E World Championship, all powertrains will be newly homologated for Season 11, allowing manufacturers and their customer teams to implement key learnings and optimisations from GEN3 into their new cars.

Mohammed Ben Sulayem, President, FIA said:

"The FIA and Formula E have been working hard on the development process of this new GEN3 Evo race car, which represents another significant leap forward in electric racing technology. I would like to thank both FIA and Formula E teams for the hard work which underlines our shared commitment to pushing the boundaries of sustainable motorsport, while delivering competitive racing."

Jeff Dodds, Chief Executive Officer, Formula E said:

"The GEN3 Evo heralds a ground-breaking chapter in the evolution of Formula E, embodying our dedication to innovation and high performance achieved sustainably. Featuring unprecedented acceleration and an advanced aerodynamic design, the car that I had the honour of unveiling in Monaco is

set to intensify the thrill of our racing, captivating our drivers and fans around the world with truly superior capabilities and performance."

Formula E

The new-look Formula E car for the next two seasons, to be known as the Gen3 Evo, will boast "acceleration 30% faster than a current Formula 1 car, and 36% faster than the current Gen3" according to the series.



The FIA and Formula E have concentrated on more potent acceleration through an active front powertrain (FPK) to be used in qualifying, the race start and during the mandatory attack modes for the Gen3 Evo which will hit the tracks publicly this November at the pre-season Valencia test.

The enhancements have been actioned largely due to complaints from drivers and teams over the overall feel and performance of the car, which fell way short of the initial hyperbole from FE's then-chiefs ahead of Gen3's debut at the start of 2023.

The Gen3 Evo will, according to Formula E, be able to accelerate “from 0-60mph in 1.82s” and will have “5-10% more grip, made from 35% recycled and sustainable materials (+9% vs Gen3 spec)”.

A new tyre compound provided by Hankook is set to provide more grip and use 35% recycled and sustainable materials.

It is being billed as the “most efficient formula car ever: An electric motor with over 90% efficiency, significantly surpassing the 40% efficiency typical of internal combustion engines”.

IT SHOULD BE A BETTER DRIVING EXPERIENCE



The Gen3 car's travails during its development in 2022 were exhaustively reported on The Race. The project was beset by difficulties, safety issues and met a general lack of enthusiasm from the drivers, who generally loathed its handling and its lack of feel.

While some of those challenges were met, several were not. But the cars did provide strong racing, mostly thanks to the innovative sporting format and the ability to overtake when the usable energy and circuit configuration allowed.

Now, the Gen3 Evo's spec FPK active (supplied by Californian-based EV engineering company Atieva and affiliated to the Ludic Motors EV brand) essentially means it will be able to run four-wheel drive, so that generating energy will aid traction and give drivers much more driveability on low and medium speed corners.

This combined with a softer, although still durable tyre compound from Hankook, should mean lap times improve by around 1 and at least 1.5 seconds at most circuits.

"I think you can have a visible difference, especially on the tight corners but not so much in the fast corners but in the tight corners," Formula E sporting and technical consultant Dieter Gass told The Race this week.

"You're going to see the difference in acceleration at the race start because we have seen now the car can accelerate below two seconds from 0 to 60 miles per hour and without front wheel drive you're above 2.5 seconds."

The initial feedback from drivers was positive after they tried the active front FPK and different compounds of Hankook rubber at a manufacturer test at Majorca last November.

One who sampled the car was Nissan's Oliver Rowland, who told The Race that "the performance of the car in general is a big step forward".

"Lap time was a couple of seconds faster; the traction is a lot improved and I think they've made a good step on the tyres," he continued.

"Could they be more aggressive? Probably I think yes.

"I still don't think that it's a tyre that's dropping off and creating massive one lap potential. It's still quite a consistent tyre over the race sim. It's a good step forward, I mean it's a good intermediate step forward let's say.

“It will depend on the track and how traction limited it is because the four wheel [drive] makes a big difference to traction, and the tyre. I would say three seconds [gain] on a technical, dusty, slippery track is about right.”

The Hankook tyres had an initial target of “improving the grip by 10%” according to Gass.

“I think we ended up somewhere between 5% and 10% grip increase, so almost at the target. The tread still looks the same, but it's a little bit less deep.”

The genesis of the Gen3 Evo was actually born out from the so-called Gen Beta car that was used for a Guinness World Records indoor acceleration bid at London ExCeL last July. The Gen3 Evo has several elements of it that have been carried over from the Gen Beta model that was driven by Lucas di Grassi and Jake Hughes in London.

The Gen3 Evo car is estimated to bring a “2% performance gain from Gen3, equating to a two secs faster qualifying lap on the Monaco circuit”, according to FE.

Formula E previously consistently stated, erroneously as it turned out, that the Gen3 car would regularly reach 200mph. It never did in events, instead registering a fastest ever straightline speed of 172mph at Portland last June.

Whether from a top end perspective Formula E’s marketing spin will be more plausible in Gen3 Evo remains to be seen but generally something around the 180/185mph mark for the revised car might be achievable depending on the tracks it visits.

FRONT WING WILL BE MORE ROBUST

Formula E went from the all-encompassing covered prototype style front bodywork section of Gen2 to the open-wheeled more conventional look of Gen3 in 2023.

One thing that changed was the intensity of the contact from one generation to the other. The more robust Gen2 cars had been able to get away with less damage from what we’ll call ‘tactical’ contact.

The more conventional open faced front-wing of Gen3 and its open-wheel set-up was a surprise because aesthetically and sportingly the Gen2 front bodywork set-up was generally popular with driver and fan alike.

The Gen3 cars too provided a bigger hole in the air than the Gen2 cars with more drag, which has been used tactically in the draft during 'peloton' races where energy can be greedily saved.

"The main target of the bodywork changes was improving drag," said Gass of the Gen3 Evo.

"The change in the front wing was one of the elements of changing drag, but at the same time Spark has looked into making it a bit more robust.

"This is a little bit of a historical discussion, I would say, between the teams and Spark. When it's too solid it is no good and when it's too brittle it's not good either.

"I think they're now halfway, and we hope that we don't see as many damages anymore as we have this year."

These have included alarming accidents last season with Nico Mueller at Portland and Nick Cassidy this season in Sao Paulo when the wing elements failed through contact and acted as skateboards on the cars.

ATTACK MODE WILL WORK

The lack of opportunity for drivers to really use the extra 50kW from running over the off-line transponder loops at each circuit and triggering attack mode has been noticeable since the first Gen3 race. Attack mode has become more about working out when to factor in the time loss from going over the loop, not something that can be used aggressively as a power boost worth having for overtaking.

While Formula E markets the countless hundreds of artificial and mostly meaningless tactical place changes in its peloton races, the reality is that very little genuine attack mode overtaking actually occurs in any given race.

That should change next season with the Gen3 Evo car.

"I think that should be helped by two things, really. One, the four wheel drive element and the second is the tyre grip," said Gass.

"Because from what the drivers were saying, in many situations, they couldn't use the extra power because they didn't have enough grip.

“This is the consequence of the traction basically. Now, drivers really should be in a position to benefit from the activated attack mode.”

The better traction and driveability of the cars should make the extra 50kW usable for overtaking moves as that grip will let drivers apply their extra power properly.

GEN4 STILL THE REAL ‘GAME CHANGER’

“Every iteration of the car I would like to look better, to perform better. That could be 'go faster' but it could also be 'go longer',” Formula E CEO Jeff Dodds told The Race recently.

Faster and longer is a neat encapsulation of what Formula E needs to achieve as it heads to Gen4 which Dodds also reckoned was “what is really exciting us now.”

That car will include a regeneration capacity up to 700kW and an increased power output up to 600kW.

But that’s for two years’ time. Gen3 Evo is just an interim step.

“From a driver point of view, you want it to be a more exhilarating thing for them to drive and you want drivers to look forward to jumping in the car,” Dodds added.

“We’ve actually done some testing on performance of the car, I won’t give the big reveal now in detail, but from an acceleration point of view it will be incredible. It will give incredible acceleration but there won’t be a huge amount of difference at the top end of this car because we’re not fundamentally changing the powertrains.

“The feedback I hear from the drivers is that it’s a nicer car to drive and is a more thrilling car for them to drive.”

The targets of Gen3 Evo are reasonably clear then - they’re what the FIA’s circuit racing chief Marek Nawarecki describes as “to see the races as attractive as they can be for fans, also for drivers, teams and the sporting format of Formula E”.

“I think that the evolutions, the upgrades that we are ready to bring to this car, will support these objectives,” he added.

“Since the beginning of this project, we took on board the different solutions to gradually improve the performance of this car, which already is quite impressive on the track in many aspects.”

But Nawarecki was a little more contained than the drivers and promoters on what the Gen3 Evo might bring forth, saying that the motivation was to “increase a certain number of parameters to give additional features in terms of traction for example, to have slightly better performance regarding the grip”.

“We believe that, all together, I would avoid saying that this will bring specifically certain effects, but I would say the global outcome for the evolution will be more performance clearly observed by the fans during the race,” he added.

A BETTER-LOOKING CAR?

Dodds believes the Gen3 Evo is a step forward aesthetically on its predecessor, having been a sceptic of the initial elegance of the Gen3 car.

"The Gen3 car is very distinctive, so when you see a Gen3 car versus an IndyCar or a Formula 2 car or a Formula 1 car, you recognise it straightaway, and one of the reasons you recognise it is that very distinctive, kind of with the triangular shape at the front of it," he said.

"Now, personally I don't love that shape, it's a very personal thing. So when I saw the designers come out of this team for Gen3 Evo, and they were saying it looks more butch on the track, it's a bit lower, sits a bit wider. It's more aerodynamic but it's got more pinched nose...maybe a slightly more traditional nose to it, I thought it looked amazing.

"All of a sudden, I went from seeing a car which was amazing and really liked the performance of but didn't love the look of, to getting the whole package looking better and is a better performing car is more aerodynamic and I think it looks butcher, it just looks more muscular on track."

HEADLIGHTS WERE CONSIDERED

Manufacturers have been asked several times about items of cosmetic interest that could enhance the recognition of their brands within the design of Formula E cars.

Two specific areas have been the possibility of lights being mounted on the cars and also an artificial noise being enhanced to make the cars more audible.

“We’ve actually had a few discussions which are always somewhat wobbling around where people want to do something,” confirmed Gass.

“One thing is the lights and the other thing is the noise. Both of them are somewhat, I would say in the clouds, in discussion, but no decision taken on that.”

Gass stated that he could “imagine that for Gen4 something is happening there but that'll depend as well on the design of the car.

“It's somehow always in the discussion, but we're not really at the stage where it's a clear push, for example, from the manufacturer saying we have to have it, that doesn't happen.

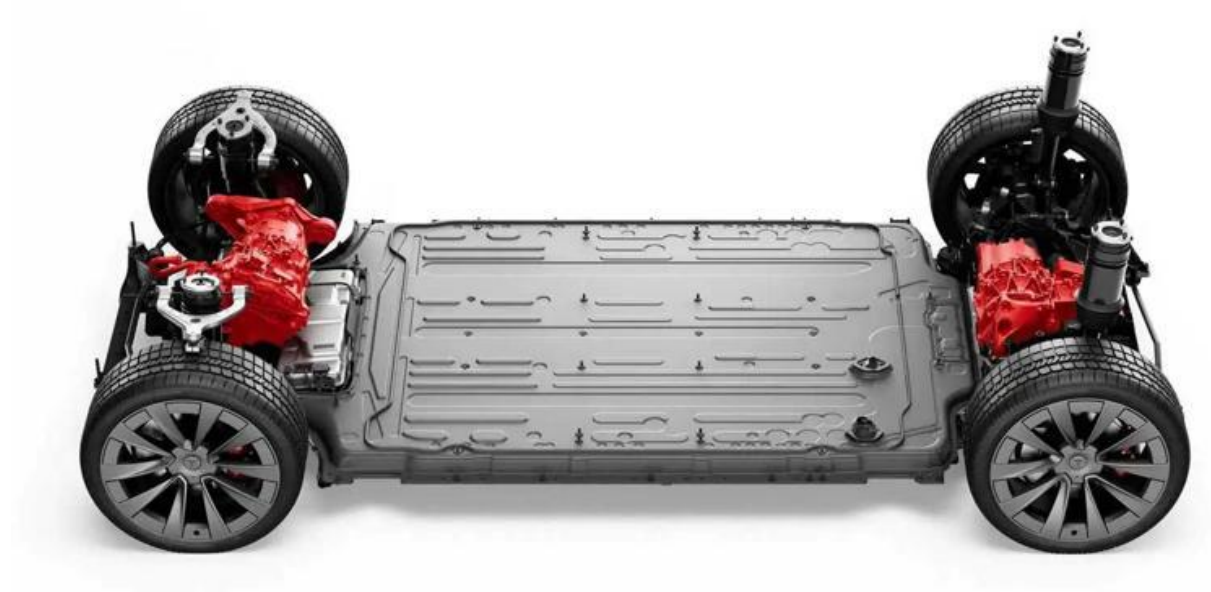
“It could happen but it is not necessarily going to happen.”



Race for the Planet

Extreme E is a radical off-road racing series in the most remote corners of the planet impacted by climate change. 8 teams, consisting of one male and one female driver, racing to highlight global issues and inspire the next generation.

The Complete Guide To Electric Vehicle Platforms



The Complete Guide To Electric Vehicle Platforms© InsideEVs

Here's a rundown of the EV platforms currently in use in America or revealed to be in development.

We're still in [the early phase of the transition to electric vehicles](#). That means building an EV remains an immense technical challenge. Manufacturers are dispensing with more than a century of combustion car development and rethinking how to build a vehicle from the ground, or in the car's case, the platform up.

There's no one right way to build an electric vehicle platform. Car companies have settled on four main development pathways.

Dedicated EV Platform

This platform is designed specifically for EVs. It permits maximum design freedom. It's scalable and modular. It can be sold to other manufacturers. It's the ideal where almost every EV manufacturer wants to be. But getting there requires years of painstaking and expensive R&D without a guaranteed return on investment — a tough sell to shareholders.

Modified Combustion Platform

Call this the "quick and dirty" route to a serviceable EV where a manufacturer retrofits an existing combustion platform. It limits EV design and capability. It's often a developmental dead end. But it is a way to get a serviceable EV on the road expediently and buy time to figure out the broader electric future.

Hybrid Platform

Some newer combustion platforms were designed for powertrain flexibility. The platform can accommodate combustion, EVs or various forms of hybrid in between. Design and capability are compromised. But manufacturers, being able to build EVs on the same line as combustion cars, have more flexibility.

EV First Platform

This is a dedicated EV platform that's designed for EVs but still capable of implementing combustion, hybrid or range-extending powertrains as needed. This may become a more popular route in the future as buyers hedge against EV skepticism.

Here's a rundown of the EV platforms currently in use in America or revealed to be in development.



BMW Neue Klasse© Provided by InsideEVs Global

BMW Neue Klasse

BMW

CLAR: CLAR stands for BMW Cluster Architecture. BMW EVs like [the i4](#) are built on this hybrid platform, which also underpins BMW combustion cars. Performance is compromised a bit compared to rivals from Mercedes. Though the BMWs counter by looking like BMWs.

iX: [BMW's iX crossover](#) runs on its own dedicated EV platform, which has been somewhat confusingly described as ["totally new"](#) but also ["highly compatible"](#) with CLAR.

Neue Klasse: [The Neue Klasse](#) will be BMW's first dedicated EV platform. It will feature more compact, energy-dense cylindrical battery cells, allowing vehicles to offer more range and fastcan accommodate capable of accommodating up to 1,341 hp from a quad-motor system. Neue Klasse should launch in 2025 with an X3-sized crossover and 3-Series-sized sedan.



2025 Mustang Mach-E Rally_05

2025 Mustang Mach-E Rally

Ford

GE1: Ford uses the Global Electrified 1 platform for [the Mustang Mach E](#). GE1 derives from the combustion C2 platform, which underpins the Ford Escape, Maverick and Brwill likelyThe platform is likely to be a one-off for the Mustang Mach E. Ford used VW's MEB platform for European EVs and is reportedly developing an updated GE2 platform.

T3: Ford builds [the F-150 Lightning](#) on a revised version of its body-on-frame T3 platform that underpins its conventional F-150 pickups. Ford has said it will launch a ["Project T3" pickup](#) on a new EV platform later this decade.



GM Ultium Platform© InsideEVs

GM Ultium Platform

General Motors

BEV3: BEV3 is GM's dedicated EV platform. It uses a skateboard layout with GM's Ultium battery technology. GM uses BEV3 for crossovers like [the Cadillac Lyriq](#), [Chevrolet Blazer EV](#) and [Chevrolet Equinox EV](#). [The Honda Prologue](#) and [Acura ZDX](#) are also built on BEV3.

BT1: BT1 is GM's platform for full-size electric pickups and SUVs, underpinning vehicles like [the GMC Hummer EV](#) and [Chevrolet Silverado EV](#). It is not related to the T1 truck platform. BT1 is technically not body-on-frame, though GM says it is not a unibody platform.



Kia E-GMP Platform

Kia E-GMP Platform

Hyundai Motor Group

E-GMP: Hyundai's Electric Global Modular Platform is a dedicated EV platform with a skateboard layout. It is known for its 800V architecture (there is a 400V for more affordable cars like the Kia EV3) and its lightning-quick 350 kW fast charging. Cars based on the E-GMP platform — [the Kia EV9](#), [Hyundai Ioniq 6](#) and [Hyundai Ioniq 5](#) — have won the last three [World Car Awards](#).



2024 Lucid Air Grand Touring© InsideEVs

Photo by: InsideEVs
2024 Lucid Air Grand Touring

Lucid

Lucid Air: The [Lucid Air](#)'s platform offers some of the most impressive performance and efficiency on the EV market with its 924-volt architecture and efficiently packaged powertrain. It delivers more than 500 miles of range (the best on the market) in its most efficient form and can accelerate from 0-60 mph in as little as 2.5 seconds.



Mercedes-Benz EQS sedan and EQE SUV EVs

Mercedes-Benz EQS sedan and EQE SUV EVs

Mercedes-Benz

EVA2: EVA2 is the current Mercedes-Benz EV platform. It's a dedicated EV platform, providing the basis for [the EQS](#) and [EQE](#) sedans and SUVs. It's a 400V architecture offering up to 200 kW fast charging.

MMA: MMA is Mercedes Modular Architecture. It's a new platform designed primarily for smaller electric vehicles (though it won't be exclusively electric). It debuted with the Concept CLA. It will support an 800V architecture with up to 250 kW fast charging.

AMG.EA: Mercedes-Benz is building a high-performance AMG EV with its own platform. It will use high-power, lightweight axial flux motors from Yasa and a high-voltage, high-performance battery. Expect car and SUV versions.

VAN.EA: Mercedes-Benz is [developing a new modular electric van platform](#), VAN.EA. It will be used for commercial and personal vehicles, with Mercedes-

Benz planning to launch a new camper van line and a mid-size luxury van in the U.S.



2024 Nissan Ariya

2024 Nissan Ariya

Nissan

CMF-EV: [The Nissan Ariya](#) uses the CMF-EV platform, a modified version of the CMF (Common Module Family) platform used by other Nissan vehicles. It's a 400V architecture offering up to 130 kW fast charging.

Nissan EV Platform: [The Nissan Leaf](#) uses an older EV platform based on the Nissan B platform. It is the only EV still using a CHAdeMO plug for fast charging.



Rivian Skateboard Platform

Rivian Skateboard Platform

Rivian

Rivian Skateboard: Rivian launched two vehicles on its initial R1 skateboard EV platform, the R1T pickup and R1S three-row SUV. Rivian [refreshed both vehicles for 2025](#), with both offering a maximum EPA range above 400 miles, along with impressive off-road capability and the ability to accelerate from 0 to 60 mph in 3.0 seconds.

Rivian Midsize: Rivian unveiled [a new smaller midsize platform](#) to underpin new R2, R3 and R3X vehicles, which will start to roll out in 2026. The new cars will be smaller than the R1 lineup, offering less capability and range. But they should be dramatically cheaper, with the R2 starting around \$45,000 and the R3 slotting beneath it.



2023 Rolls-Royce Spectre

2023 Rolls-Royce Spectre

Rolls-Royce

Architecture of Luxury: [The Rolls-Royce Spectre](#) runs on the Architecture of Luxury platform (yes, that's actually the name), which forms the basis for Rolls-Royce's combustion models. The Spectre packs dual BMW electric motors, putting out 577 horsepower and provides up to 291 miles of range.



Stellantis STLA Large Platform

Stellantis STLA Large Platform

Stellantis

STLA: Stellantis unveiled four STLA (pronounced "Stella," Marlin Brando exclamation optional) platforms: Small, Medium, Large and Frame. The company calls them EV-first or EV-native platforms, designed for EVs but compatible with combustion and hybrid engines. [The Jeep Wagoneer S](#) and [Dodge Charger Daytona](#) will use the STLA Large platform. [The Ram 1500 REV](#) and [Ramcharger](#) ride on the STLA Frame truck platform.



Toyota: here's the e-TNGA platform

Toyota: here's the e-TNGA platform

Toyota

e-TNGA: e-TNGA is the electric version of Toyota's New Global Architecture platform. It underpins [the Toyota bZ4X](#), [Lexus RZ](#) and [Subaru Solterra](#). The cars have been praised for their driving dynamics and ripped for range and charging tech well below the standard competitors offer. Toyota is reportedly working on a dedicated EV platform to replace it.



Tesla Cybertruck Turo owner9

Photo by: Dustin Liu
Tesla Cybertruck

Tesla

Model S/Model X: Tesla's first ground-up EV after the roadster was the Model S full-sized sedan. The brand followed that up with an SUV based on it, the three-row Model X. Those vehicles, launching in 2013 and 2016, respectively, are still being sold, albeit with substantial updates.

Model 3/Model Y: Tesla moved downmarket with the smaller, cheaper Model 3 and followed that up with the Model Y crossover version. Tesla moved to streamline production with this platform. At launch, the Model Y shared more than 70% of its components with the Model 3.

Cybertruck: Tesla's third vehicle is [the Cybertruck](#). It's a unibody truck platform. The Cybertruck is the first Tesla to upgrade to an 800V architecture, though it [charges at similar speed to 400V competitors](#).



Volkswagen Group all-electric cars, based on the MEB platform

Volkswagen Group all-electric cars, based on the MEB platform

Volkswagen Group

MEB: Volkswagen's Modular Electric Toolkit is VW's first dedicated EV platform used for more affordable EVs. It's a modular skateboard platform with a flat floor, allowing ample cargo and passenger space. It's the basis for the [Volkswagen ID.4](#), [ID. Buzz](#) and [Audi Q4 E-Tron](#). Ford uses it for crossovers in Europe.

MLB Evo: Audi's first EV, now called [the Q8 E-Tron](#), runs on MLB Evo, a modified version of Volkswagen's MLB combustion platform, used for cars like [the Lamborghini Urus](#) and [the Porsche Cayenne](#).

J1: J1 is a high-performance sporty EV platform used by Porsche for [the Taycan](#) and Audi for [the E-Tron GT](#). The J1 platform offers an 800V architecture and up to 270 kW fast charging.

PPE: Premium Platform Electric is a new modular platform developed for Porsche and Audi. It's intended for larger EVs and is debuting with [the Porsche Macan EV](#) and [Audi Q6 E-Tron](#). Like the J1 platform, PPE has an 800V architecture. It can

also feature a “performance rear axle” with the rear motor situated further back for rear-biased driving dynamics.

SSP: Scalable Systems Platform is the next-gen modular EV platform from VW Group. It’s intended to replace MEB and other platforms, bringing in greater standardization to reduce costs. [The SSP rollout has been delayed](#) until the late 2020s.



Volvo EX90 First Drive

Photo by: Volvo

Volvo EX90 First Drive

Volvo/Polestar

CMA: CMA, Compact Modular Architecture, is Volvo’s midsize car platform used for electric and combustion models. It underpins [the Polestar 2](#) and the Volvo’s XC40 Recharge and C40 Recharge vehicles.

SPA2: SPA2, Scalable Product Architecture 2, is Volvo’s dedicated EV platform, debuting with [the Volvo EX90](#) and [Polestar 3](#) crossovers. The cars have a 400V

architecture that provides up to 250 kW of fast charging. Volvo has said it is developing a more capable SPA3 architecture to replace it.

Game-changing battery technology: Safer, non-flammable, and 10x more efficient than lithium

[Lithium-ion batteries](#) power a global shift toward cleaner energy. Yet, they pose significant limitations, especially in industrial and densely populated areas. Their flammability and toxicity make them unsuitable for large-scale energy storage in environments like city centers or industrial plants.

A breakthrough from [Alsym Energy](#) offers a safer, more sustainable alternative. Their new battery technology, developed with relatively abundant and stable materials, relies on a water-based electrolyte. The innovation is poised to fill critical gaps in renewable energy storage and industrial decarbonization.

A Safer, Sustainable Energy Solution

"Renewables are intermittent, so you need storage," explains Kripa Varanasi, an MIT professor and Alsym co-founder. "To truly solve the decarbonization problem, we need affordable batteries that can be made anywhere."

Unlike traditional lithium-ion batteries, Alsym's design is nonflammable and nontoxic, removing barriers to deployment in sensitive environments. Mukesh Chatter, Alsym's co-founder and CEO, highlights its transformative potential: "No chemical or steel plant would dare put a [lithium battery](#) on their premises. Industrial emissions are a much bigger problem than passenger cars, and this approach offers a new path."

The battery's electrodes are primarily composed of manganese oxide and other metal oxides, while its water-based electrolyte eliminates fire risks. This chemistry

enables batteries to be packed tightly, reducing size and cost without the need for heavy safety equipment. Existing lithium-ion manufacturing facilities can easily adapt to produce these batteries, further reducing operational costs.

Chatter's journey toward revolutionizing battery technology began with a desire to address global energy inequities. After losing his mother to cancer in 2012, he sought to focus on technologies with the potential to improve the lives of at least a billion people. [Access to electricity](#), he realized, was a critical need.

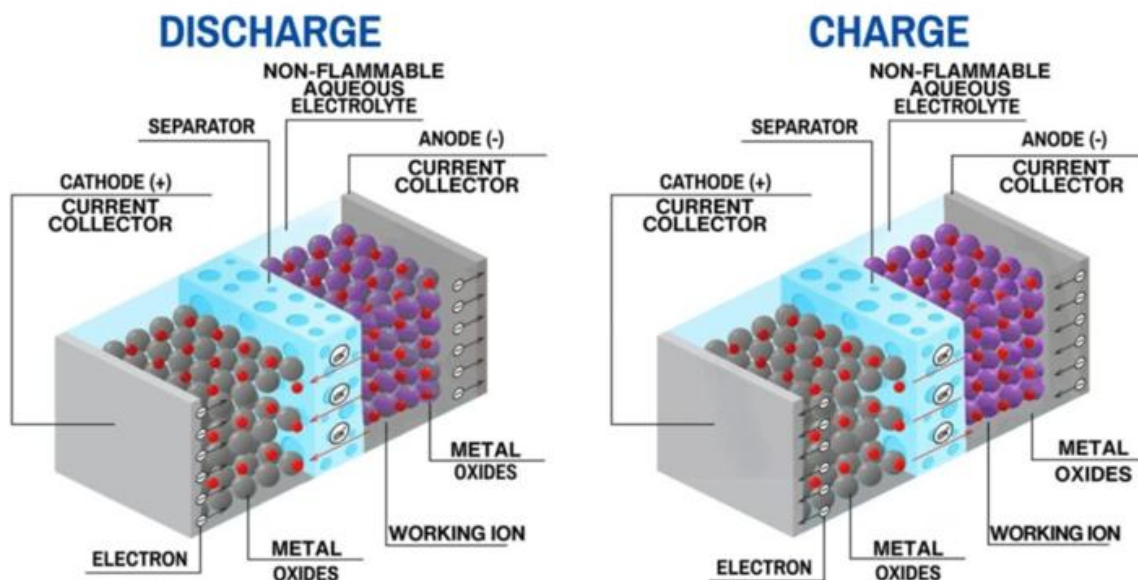
"When you don't have electricity, you lose access to essentials like the internet, cell phones, and education," Chatter explains. Determined to create an affordable and safe energy solution, he collaborated with experts including Varanasi, Rensselaer Polytechnic Institute professor Nikhil Koratkar, and researcher Rahul Mukherjee.

Despite initial challenges in recruiting researchers, Chatter's determination led to the formation of Alsym Energy. By 2020, the team had finalized their innovative battery chemistry after exploring various alternatives.

Revolutionizing Energy Storage

The battery's design addresses a range of needs. While its energy density is slightly lower than [lithium-ion batteries](#), its adaptability shines. A 20-foot container of Alsym batteries stores 1.7 megawatt-hours of electricity and supports fast charging within four hours. It can also discharge power over durations ranging from two to 110 hours, making it suitable for diverse applications.

"We're highly configurable," Chatter notes. "This flexibility is critical for scenarios like running two solar cycles a day or combining solar and wind for continuous power."



While Alsym and lithium-ion cells may look similar, they take advantage of inherently non-flammable and non-toxic materials, and their electrolyte is water-based. (CREDIT: Alsym)© The Brighter Side of News

Alsym's technology supports [renewable energy](#) sources and caters to sectors previously underserved by conventional batteries. Industries such as chemical manufacturing, metal processing, and data centers now have safer, greener energy storage options. As artificial intelligence and digitalization expand, data centers face rising energy demands. Varanasi emphasizes the opportunity: "We must power the AI and digitization revolution without compromising our planet."

The company has also started field testing with customers worldwide. These tests include collaborations with municipalities, utilities, generator manufacturers, and providers of residential and commercial power. Discussions are underway with chemical and metal processing facilities to reduce their carbon footprint using Alsym's storage solutions.

A Platform for Broader Innovation

Alsym's innovation isn't confined to a [single battery design](#). Varanasi describes the company as a "platform for energy storage," capable of supporting multiple chemistries for diverse applications. This flexibility reduces reliance on any single material, mitigating supply chain pressures.



Alsym has been manufacturing prototypes at a small facility in Woburn, Massachusetts for the last two years. Pictured is a view of the Alsym facility. (CREDIT: Alsym)© The Brighter Side of News

"When you use a single material globally, you risk running out of it," Varanasi explains. "Our platform has already enabled us to develop three or four additional chemistries, each targeted at specific applications."

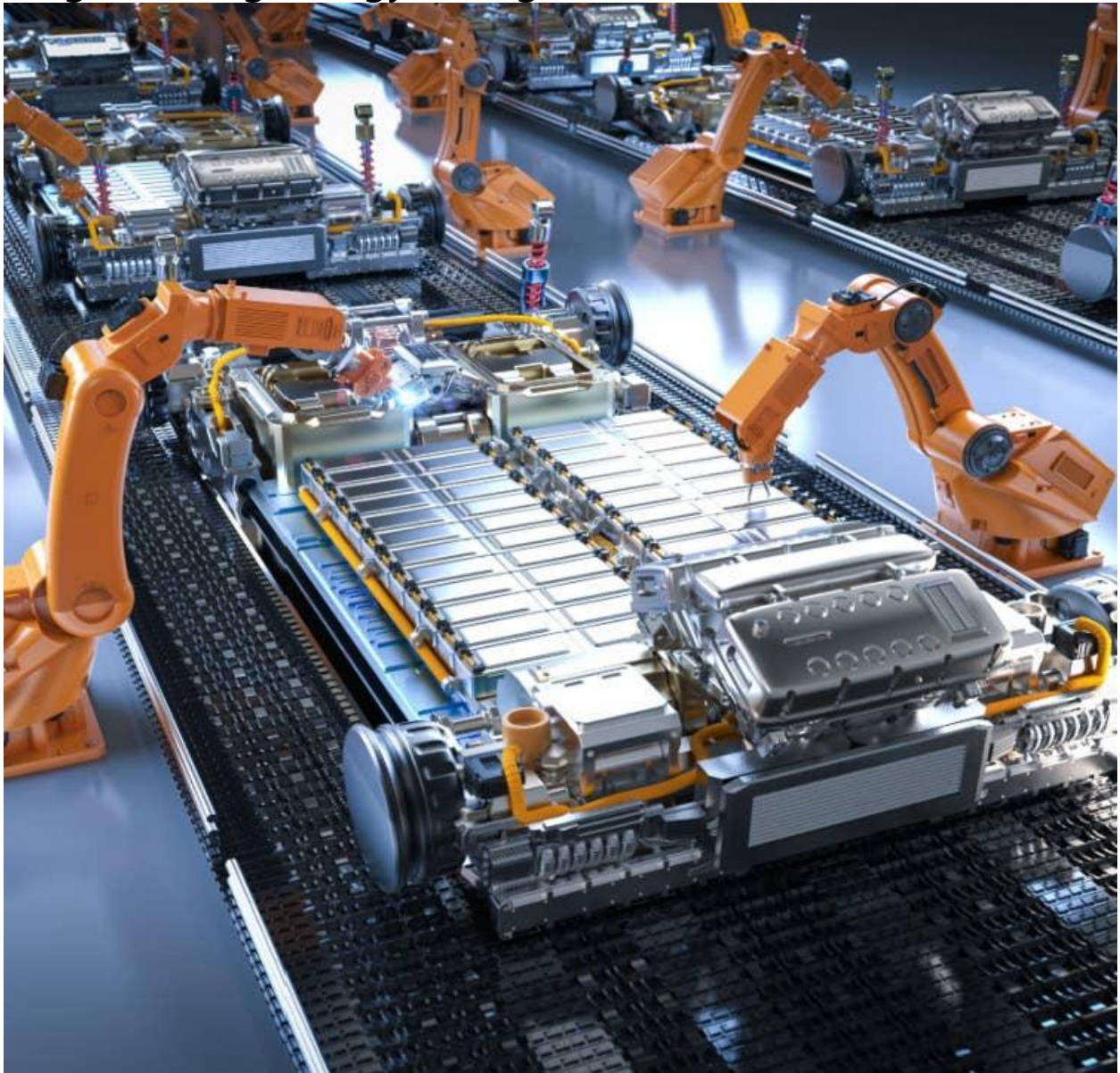
Alsym's technology also tackles intermittent challenges faced by [electrolyzers](#) in green hydrogen production. By providing a reliable and sustainable storage solution, the company is contributing to global decarbonization efforts across industries.

Chatter's original goal—to [bring electricity to a billion underserved people](#)—remains central to Alsym's mission. But the potential applications extend far beyond. With the ability to decarbonize industrial sectors, support renewable energy, and meet rising data center demands, Alsym's batteries could drive profound global change.

"We started wanting to light up homes for a billion people," Chatter reflects. "Now, we have a chance to impact the entire globe by cutting industrial emissions."

Breakthrough graphene technology revolutionizes battery safety and performance

Graphene enhances lithium-ion battery safety with superior heat management, paving the way for safer, longer-lasting energy storage solutions.



Swansea University researchers have developed a revolutionary graphene foil that enhances lithium-ion battery safety. (CREDIT: Shutterstock)

Share this story

Researchers from Swansea University, in collaboration with [Wuhan University of Technology](#) and [Shenzhen University](#), have developed a breakthrough technique for producing large-scale graphene current collectors. This new advancement could significantly improve lithium-ion battery (LIB) safety and performance, addressing critical challenges in energy storage technology.

The findings, published in [Nature Chemical Engineering](#), outline the first successful approach for creating defect-free graphene foils on a commercial scale, an achievement that could reshape the future of battery technology.

Graphene, a material known for its exceptional properties, now promises extraordinary thermal conductivity in current collectors. The graphene foils developed by this team can conduct heat at up to $1,400.8 \text{ W m}^{-1} \text{ K}^{-1}$ —almost ten times greater than traditional copper and aluminum current collectors used in lithium-ion batteries.

This enhanced conductivity plays a crucial role in efficiently managing the intense heat generated within high-energy [lithium-ion batteries](#), such as those used in electric vehicles.

A scalable graphene current collector featuring high thermal and electrical conductivity has been developed to address the crucial thermal problems in lithium-ion batteries. (CREDIT: Swansea University)

Dr. Rui Tan, a co-lead author from [Swansea University](#), highlights the importance of this development, stating, “Our method allows for the production of graphene current collectors at a scale and quality that can be readily integrated into commercial battery manufacturing.

This not only improves battery safety by efficiently managing heat but also enhances energy density and longevity.” By replacing traditional metal collectors, graphene-based collectors offer a safer alternative by preventing the buildup of extreme heat, which can lead to battery failure and even fires or explosions.

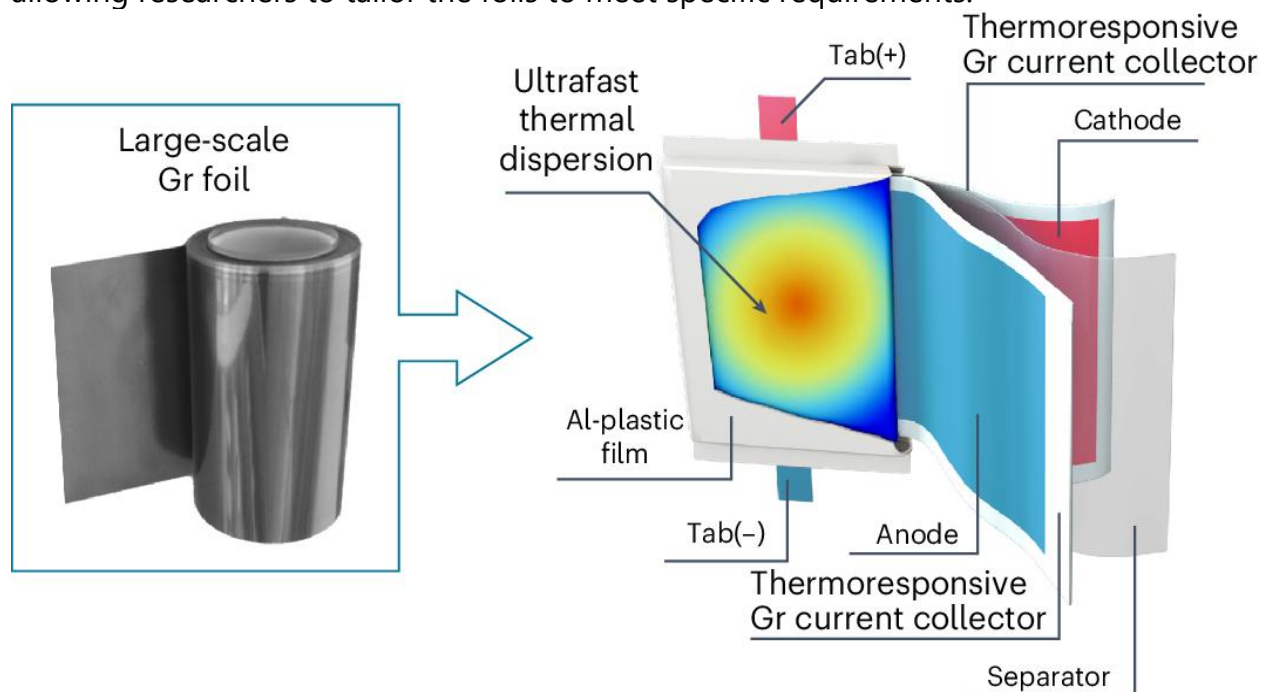
One of the most significant challenges in [battery technology](#) is preventing thermal runaway—a dangerous condition in which a battery generates excessive heat that it cannot dissipate, leading to potential failure. These new graphene foils are designed to dissipate heat more effectively, reducing the likelihood of thermal runaway.

“Our dense, aligned graphene structure provides a robust barrier against the formation of flammable gases and prevents oxygen from permeating the battery cells, which is crucial for avoiding catastrophic failures,” explained Dr. Jinlong Yang, another co-lead author from Shenzhen University.

Beyond heat management, these graphene foils show remarkable durability. In a key demonstration, the researchers produced a 200-meter-long graphene foil with a

thickness of just 17 micrometers. This foil retained high [electrical conductivity](#) even after being bent over 100,000 times, showcasing its flexibility and resilience. Such durability makes the material suitable not only for batteries but also for flexible electronics and other advanced applications.

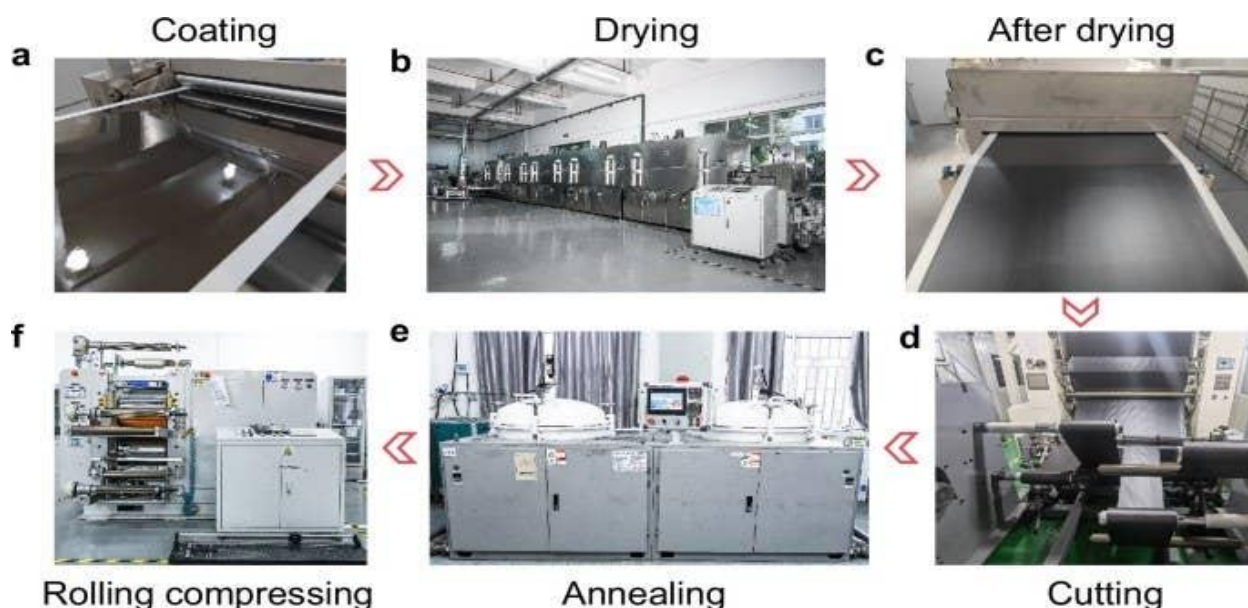
The scalability of this process marks a significant leap for graphene applications. The technique enables the production of graphene foils in customizable thicknesses, allowing researchers to tailor the foils to meet specific requirements.



Graphite cells integrated with these temperature-responsive foils show faster heat dissipation, eliminating the local heat concentration and circumventing the fast exothermic aluminothermic and hydrogen-evolution reactions. (CREDIT: Nature Chemical Engineering)

For instance, thicker foils could enhance durability in high-stress applications, while thinner foils might be ideal for situations requiring lighter materials. This adaptability opens doors for safer, more efficient energy storage systems across a range of sectors. Looking forward, the impact of this innovation could be substantial, especially in industries like [electric vehicles](#) and renewable energy systems, where efficiency and safety are paramount. These graphene foils could improve battery safety, energy density, and overall performance, making them an attractive option for electric vehicle manufacturers who prioritize safety and longevity.

The research team is continuing to refine this technology with ongoing efforts aimed to reduce the thickness of graphene foils even further while enhancing their mechanical properties. The team is also exploring additional applications for this material, including redox flow and sodium-ion batteries, with support from Professor Serena Margodonna's group at Swansea University.

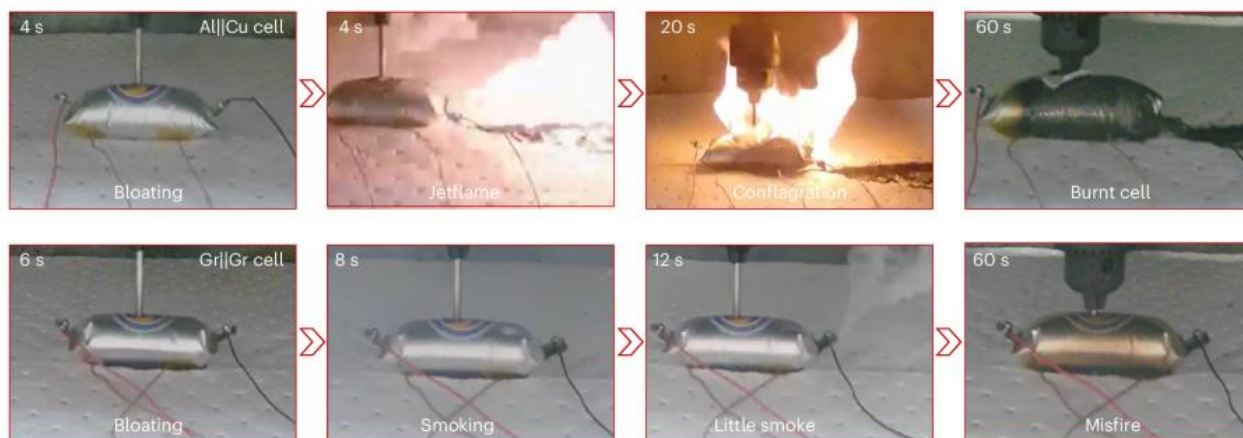


Fabrication of the large-area Gr using GO+3wt.% PEA precursor. (CREDIT: Nature Chemical Engineering)

Thermal runaway is one of the most pressing safety issues in lithium-ion batteries. When the internal temperature of a battery exceeds a critical threshold, the battery can begin to produce heat faster than it can dissipate it. This can lead to a cascade of exothermic reactions, resulting in [battery failure](#). Traditional metal current collectors, such as aluminum and copper, are limited in their ability to transfer heat efficiently, making them inadequate for high-energy-density batteries.

The newly developed graphene current collectors address these limitations. Their high thermal conductivity enables rapid heat transfer, which helps to maintain safe operating temperatures within the battery cells. As a result, the battery's internal structure remains stable, preventing the chemical reactions that lead to thermal runaway. Graphene's unique structure not only serves as a robust thermal conductor but also acts as a barrier to oxygen, further enhancing the battery's safety profile.

In practical applications, lithium-ion batteries with these graphene foils demonstrated faster heat dissipation. This helps prevent local heat concentration within [battery packs](#), a primary contributor to thermal failure. Batteries equipped with these graphene current collectors were able to maintain stable temperatures, avoiding the fast exothermic reactions that can occur with aluminum and copper foils. This characteristic makes graphene current collectors ideal for high-performance applications, especially in electric vehicles, where safety standards are stringent.

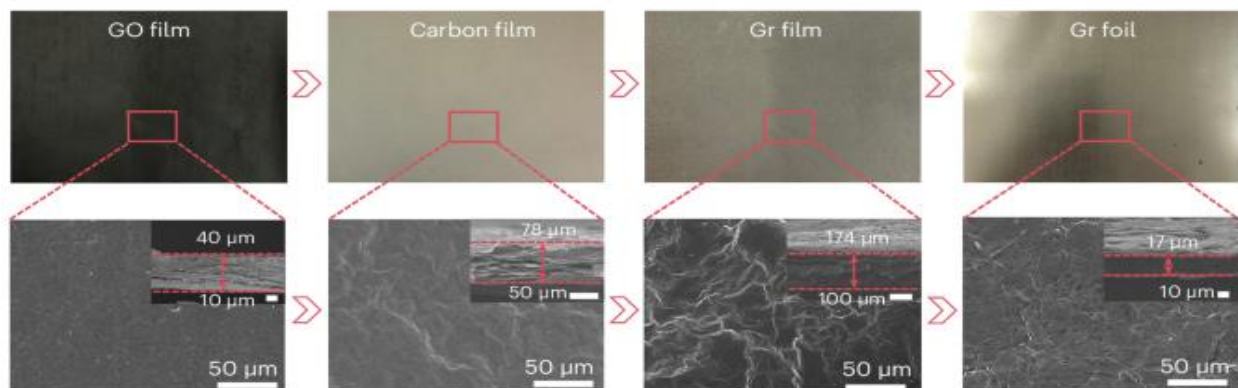
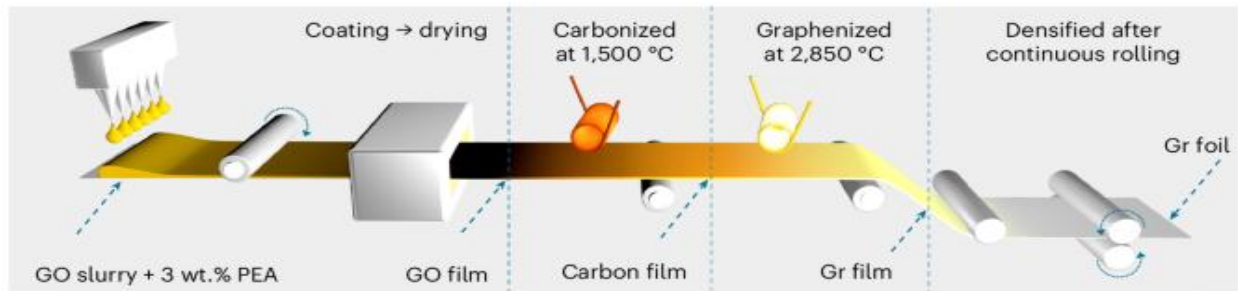


Safety performance and mechanism analysis of pouch cells during thermal runaway. (CREDIT: Nature Chemical Engineering)

Overall, this innovative approach offers a solution to one of the most significant challenges in battery technology. Graphene foils are not just a laboratory success; they are ready for commercial production on a large scale. By enabling the fabrication of these foils in lengths ranging from meters to kilometers, this technology promises to drive the next generation of energy storage solutions.

The potential of graphene in this role extends beyond [lithium-ion batteries](#). The researchers are exploring applications in other types of batteries, like sodium-ion and redox flow batteries, where high thermal conductivity and flexible design are advantageous.

With this development, the research team has paved the way for safer, more efficient batteries. This is a crucial advancement as the world moves toward renewable energy and electric mobility, both of which demand high-performance, reliable, and safe energy storage solutions.



Fabrication of the large-area Gr foil. (CREDIT: Nature Chemical Engineering)

The innovation not only addresses safety concerns but also offers practical solutions for extending battery lifespan and optimizing energy use in various applications.

Note: Materials provided a

Massive battery innovation could extend EV range to over 3,000 miles on a single charge

In the world of electric vehicles (EVs), a breakthrough in battery technology is set to significantly enhance energy storage capacity.

Understanding the Role of the Anode in Batteries

The key to understanding battery function lies in the anode, the component responsible for storing power during charging and then releasing it when the battery is in use. In most modern [lithium batteries](#), graphite is the predominant material used for anodes.

Professors Soojin Park and Youn Soo Kim of POSTECH. (CREDIT: POSTECH)

However, materials like silicon offer much greater energy [capacity than graphite](#), making them highly desirable for more efficient battery designs. The challenge, however, has always been in stabilizing a battery that uses a silicon anode. Silicon tends to expand during internal reactions within the battery, which can compromise its stability and safety.

A Breakthrough in Silicon Anode Technology

Professors Soojin Park and Youn Soo Kim of POSTECH, in collaboration with Professor Jaegeon Ryu of Sogang University, have developed a groundbreaking solution to this long-standing issue. They have engineered a special binding material that prevents a high-capacity silicon anode from expanding. The result is a [lithium battery](#) with ten times the capacity of those with graphite anodes.

While POSTECH's achievement is remarkable, they are not the only ones in the global race to revolutionize battery technology. Numerous teams around the world are working on more sustainable and efficient solutions.

For example, a Chinese company has developed an [EV battery](#) that uses sodium, a material that is both affordable and widely available, as a viable alternative to the more expensive lithium.

Meanwhile, NASA is advancing [solid-state battery](#) technology, which promises to be both more compact and lightweight compared to traditional lithium batteries.

Additionally, another researcher is exploring the creation of biodegradable batteries using crab shells.

The team introduced polyethylene glycol to regulate the physical properties and facilitate Li-ion diffusion, resulting in the thick high-capacity electrode and maximum energy density found in Li-ion batteries. (CREDIT: Wiley)

Towards a Greener Future

The implications of these advancements in battery technology extend far beyond transportation. Efficient batteries are essential for optimizing cleaner energy sources, such as wind and solar power. Unlike fossil fuels, which can deliver energy on demand, renewable sources like [solar and wind](#) depend on weather conditions.

As a result, efficient storage solutions are crucial to capture energy during optimal conditions and supply it during less favorable times, such as at night or on windless days.

In the context of electric vehicles, more powerful batteries mean longer driving ranges. The ability to store more energy could make EVs as efficient, if not more so, than their [gasoline-powered](#) counterparts.

All-solid-state lithium batteries have emerged as a priority candidate for the next generation of safe and energy-dense energy storage devices surpassing state-of-art lithium-ion batteries. (CREDIT: Wiley)

Reflecting on this significant achievement, Professor Park stated on the POSTECH website, "The research holds the potential to significantly increase the energy density of lithium-ion batteries through the incorporation of high-capacity anode materials, thereby extending the [driving range of electric vehicles](#)." He also highlighted the transformative potential of silicon-based anodes, noting, "Silicon-based anode materials could potentially increase the driving range at least tenfold."

As the world moves toward a greener future, it is clear that advances in battery technology will play a central role in this transition, driving the shift away from polluting energy sources. With these recent developments, that future seems closer than ever.

Note: Materials pro

EV battery breakthrough doubles range to over 700 miles per charge

The Achilles' heel of lithium metal batteries lies in their rapid energy storage capacity loss after a few cycles of charging and discharging

The Achilles' heel of lithium metal batteries lies in their rapid loss of energy storage capacity after just a few cycles of charging and discharging.

[Stanford scientists](#) have unveiled a breakthrough in lithium metal battery technology that could pave the way for cars to travel 700 miles on a single charge, effectively doubling the range of today's conventional lithium-ion batteries.

However, while the promise is tantalizing, the journey towards realizing this potential hasn't been without its obstacles.

The Achilles' heel of [lithium metal batteries](#) lies in their rapid loss of energy storage capacity after just a few cycles of charging and discharging. This drawback is highly inconvenient for drivers who rely on rechargeable electric cars to sustain years of operation.

Magnified image of a copper mesh from a lithium metal battery in the discharged state. Tiny pieces of dead lithium of various sizes and shapes are deposited on square openings in the mesh. (CREDIT: Wenbo Zhang/Stanford University)

In the pursuit of enhancing battery longevity, researchers at Stanford University have made a significant stride forward, offering a simple yet effective solution.

Wenbo Zhang, a PhD student in materials science and engineering at Stanford and co-lead author of the study, elucidated their approach: "We were looking for the easiest, cheapest, and fastest way to improve [lithium metal](#) cycling life."

Their discovery, detailed in a study published in the [journal Nature](#), involves draining the battery and allowing it to rest for several hours. This seemingly straightforward method proved to be remarkably effective, rejuvenating battery capacity and enhancing overall performance without necessitating costly equipment or material alterations.

Senior author Yi Cui, a prominent figure in materials science and engineering, emphasized the practical implications of their findings for EV manufacturers. "Our results can provide practical insights for adapting lithium metal technology to real-world driving conditions," Cui remarked.

Indeed, the significance of this advancement cannot be overstated as it lays the groundwork for the widespread commercial adoption of lithium metal batteries, potentially revolutionizing the [EV landscape](#).

Technically, it's essential to distinguish between lithium metal and lithium-ion battery technologies. Traditional lithium-ion batteries feature graphite anodes and lithium metal oxide cathodes, separated by an electrolyte medium that facilitates the transfer of lithium ions.

A micron-size piece of isolated lithium is trapped in the solid electrolyte interphase (SEI) matrix when a lithium metal battery discharges. Center images: The matrix dissolves when the battery is at rest, enabling the isolated lithium to reconnect with the anode during charging. Far right: New SEI matrix forms during the next discharge cycle. (CREDIT: Wenbo Zhang/Stanford University) Conversely, lithium metal batteries replace the graphite anode with electroplated [lithium metal](#), effectively doubling the energy storage capacity in the same volume.

Philaphon Sayavong, a PhD student in chemistry and co-lead author of the study, elucidated the significance of this substitution: "A car equipped with a lithium metal battery would have twice the range of a lithium-ion vehicle of equal size."

This leap in efficiency could potentially eradicate range anxiety among drivers hesitant to [embrace EVs](#). However, the rapid degradation of lithium metal batteries due to continuous cycling poses a formidable challenge, threatening to undermine their viability for widespread adoption.

Resting restores performance of discharged lithium-metal batteries. (CREDIT: Nature)

The key culprit behind this degradation lies in the formation of a solid electrolyte interphase (SEI) matrix, which traps isolated pieces of lithium metal during battery discharge.

Wenbo Zhang shed light on this phenomenon: "The SEI matrix surrounds isolated pieces of lithium metal stripped from the anode and prevents them from participating in any electrochemical reactions." As a result, these isolated [lithium fragments](#) are rendered inactive, contributing to the battery's diminished capacity over time.

Drawing inspiration from their previous work, which demonstrated the dissolution of the SEI matrix during idle battery periods, the Stanford team embarked on a novel experiment. By allowing the battery to rest in a discharged state, they observed a remarkable phenomenon: the dissolution of residual SEI matrix and subsequent recovery of dead lithium fragments.

Operando optical microscopy of Li isolation and reconnection under continuous cycling. (CREDIT: Wenbo Zhang/Stanford University)

Philaphon Sayavong spoke further on the significance of this discovery: "When you recharge the battery, the dead lithium will reconnect with the anode, because there's

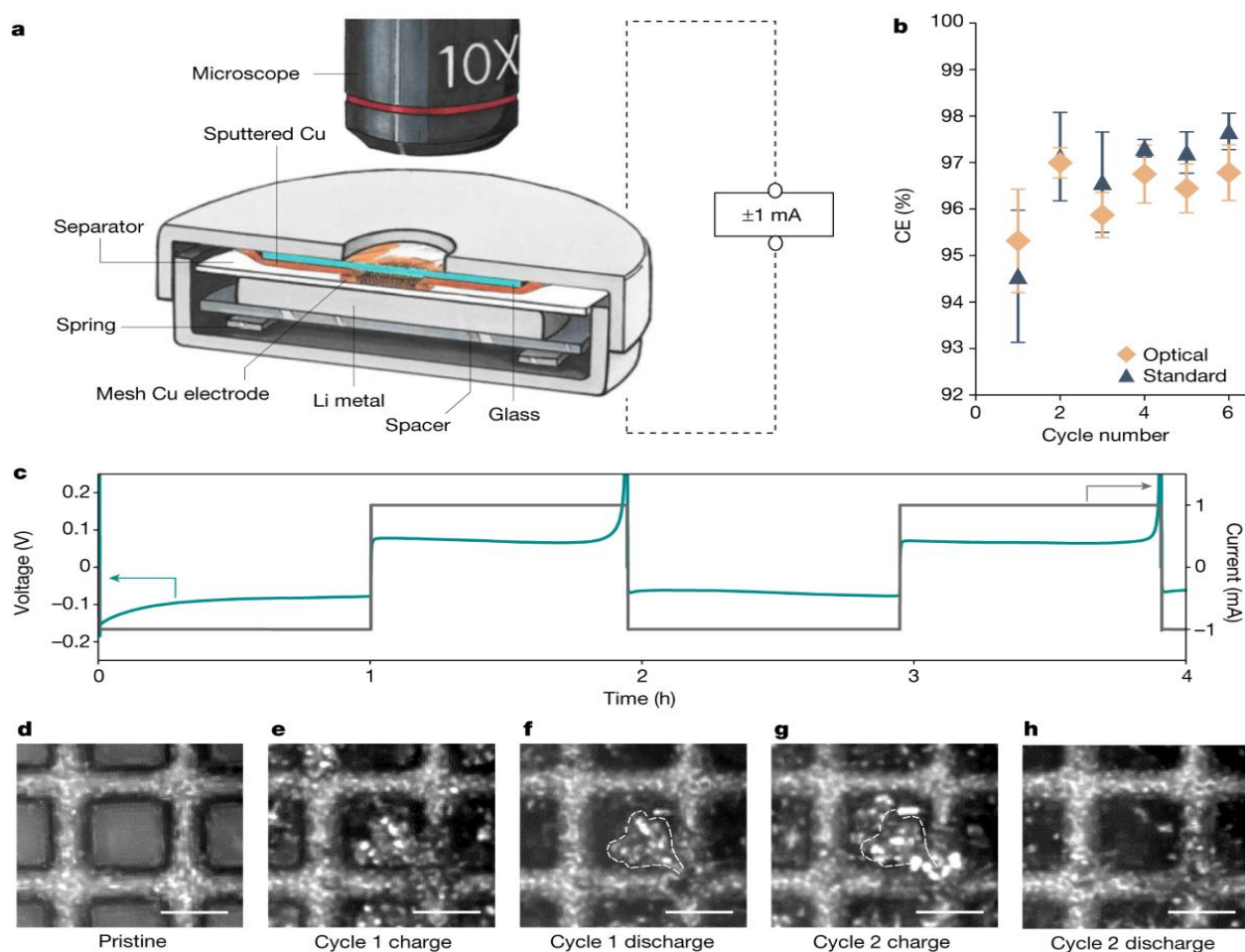
less solid mass getting in the way." This process effectively [revitalizes the battery](#), restoring lost capacity and extending its cycle life.

The practical implications of this discovery are far-reaching. Given that the average American driver spends approximately an hour per day behind the wheel, the notion of resting a car battery for several hours is eminently feasible.

Moreover, implementing this protocol doesn't necessitate expensive manufacturing overhauls. Wenbo Zhang highlighted the simplicity of their approach: "You can implement our protocol as fast as it takes you to write the [battery management system code](#)."

The breakthrough achieved by Stanford researchers offers a glimmer of hope, potentially heralding a new era of electric mobility characterized by unprecedented range and reliability.

As the automotive industry continues to embrace innovation, the realization of [next-generation electric vehicles](#) powered by lithium metal batteries may be closer than we think.



What Are Solid-State Batteries?

Solid-state batteries are, on paper, superior to the lithium-ion batteries most commonly used in EVs, but they're not ready to take over yet.

Electric vehicles are great, but they would be even better if they didn't have to lug around a big and very heavy battery pack. Making EV batteries smaller, safer, and more power-dense are top priorities for all manufacturers, but each is a challenge in its own right, and we've only seen incremental advancements over the last decade or more.

The lithium-ion batteries that are in most EVs today can be traced back to a concept introduced in 1991, and they were developed primarily for use in consumer electronics such as laptops. Through incremental improvements, they became good and cheap enough to be the go-to solution for automotive traction batteries. However, even though billions are being poured into battery research today, the limitations aren't easy to overcome, and automakers are looking for a breakthrough solution that will fix all the problems of lithium-ion or [the newer lithium polymer \(LFP\) batteries](#).

Solid-state batteries might be the breakthrough that the industry is looking for, but it's still unclear when they will reach production vehicles. They are already used in small devices such as smartwatches and even medical implants, but we've not seen them used in many larger applications yet.

But even once the technical issues are ironed out, there will still be [the issue of solid-state battery cost](#). They are expected to be around three or four times more expensive than lithium-ion batteries.

Why Are Solid-State Better EVs Than Lithium-Ion Or LFP?



Unlike current EV batteries, which use either a liquid or a gel electrolyte, solid-state batteries use a solid electrolyte. In a current-gen lithium-ion battery, lithium salts are dissolved in a solvent, resulting in a volatile liquid that floods the entire cell, while in solid-state batteries, the electrolyte can be either a ceramic, a sulfide, or some other type of solid-state material. It serves the same purpose of allowing electrons to flow between a battery's cathode and anode.

By eliminating the flammable liquid electrolyte, solid-state batteries are made much safer in the event of an accident. Solid-state cells will not only be able to hold their shape better, but even if they are breached, the chance that it will result in [a massive battery pack fire](#) is much lower thanks to their higher tolerance to high temperatures. As a result, the chance of a cell short circuit is also much lower.

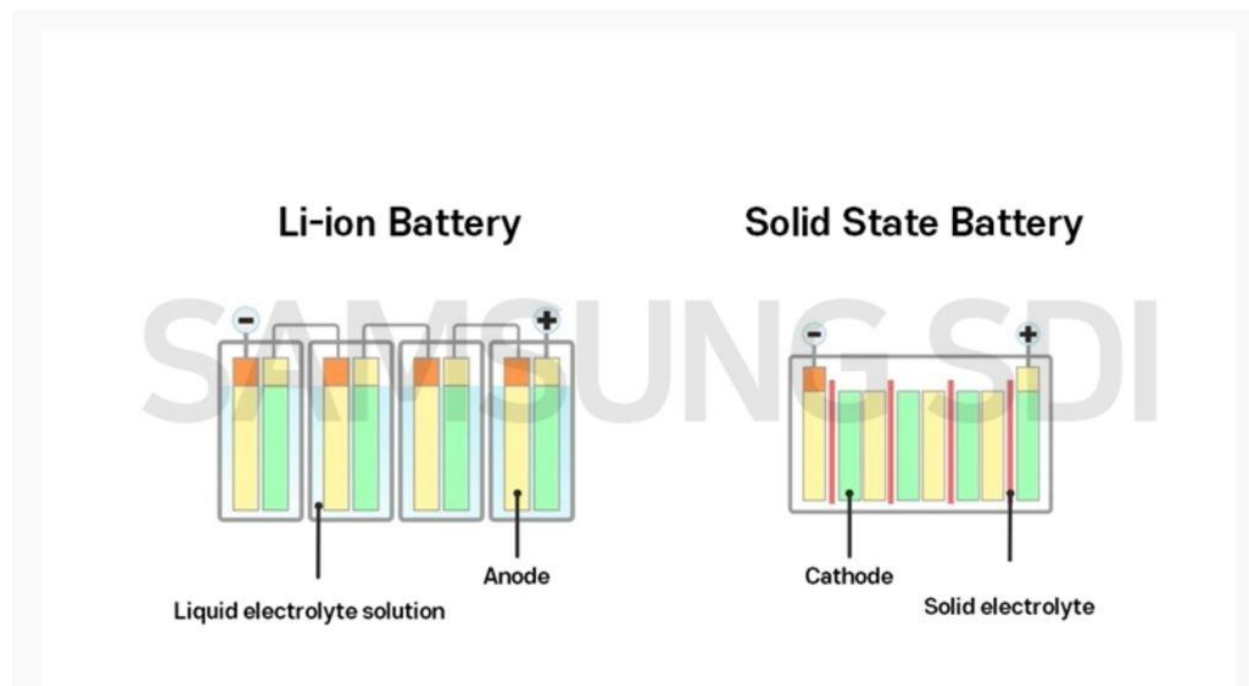
This also reduces the chance of [thermal runaway](#), which is a chain reaction where battery cells will overheat and potentially combust, and this will spread from one cell to another, eventually consuming the entire pack.

Solid-state batteries can be over twice as energy-dense as current lithium-ion batteries. This means an EV's battery pack would require fewer battery cells for the same capacity, and the pack would be lighter, thus improving the vehicle's range, performance, and handling. The pack would also be physically smaller, so it wouldn't have to take up the entire bottom of the car, thus allowing for improved interior use of space and more room for passengers or cargo.

With designs like the solid-state lithium-metal battery, the cells themselves are shorter, so even in a battery pack where the cells are placed vertically, you can still make the pack thinner.

Electrolyte degradation due to repeated thermal cycles caused by charging a lithium-ion battery pack is one way current [EV batteries lose capacity over time](#). Solid-state batteries have a much more stable electrolyte, so they should last much longer while maintaining more capacity.

Another advantage of solid-state batteries is that they can potentially charge quicker and not get damaged when regularly fast-charged to 100 percent. Current lithium-ion batteries like to be kept between 20 and 80 percent state of charge for the longest possible life, but this would not be a requirement with solid-state.



[A downsized solid-state battery(right) with the same capacity as the Li-ion battery(left)]

Improved cold weather performance is another area where solid-state is better. Solid-state batteries can withstand a wider range of temperatures, and they should be less affected by outside temperatures. This means they would retain more [charge in freezing temperatures](#) and also allow for higher charging speeds under the same conditions.

Toyota, the automaker with the most advanced in-house solid-state battery research project, says that it should offer 20 percent more range compared to its still unreleased next-gen lithium-ion and lithium iron phosphate batteries. It should allow EVs to exceed 620 miles of range, and charge from 10 to 80 percent in about 10 minutes.

When Are Solid-State Batteries Coming To EVs?

Toyota has been somewhat cryptic when it comes to revealing its solid-state battery plans. In [its battery-powered vehicle rollout roadmap](#), Toyota revealed it aimed to have solid-state batteries ready for commercial use by 2028 (although a recent report suggests they may arrive even sooner). The manufacturer confirmed that the first solid-state batteries will be introduced in its hybrid vehicles, not full EVs.

Just like Toyota, Nissan has also vowed to [launch a solid-state EV by 2028](#), and it already has a prototype production facility up and running capable of making the batteries in-house. Hyundai recently filed a patent for an all-solid-state battery in the US, and it [plans to put these batteries into production](#) EVs before 2030.

BMW is working with Solid Power to develop solid-state batteries, but its goal is to eventually move development in-house and not rely on a third party. The Bavarian automaker will launch a brand [new bespoke EV platform called Neue Klasse in 2025](#), but it won't feature solid-state cells until closer to the end of the decade.

Dongfeng is an automaker working on solid-state batteries, and its Nammi 01, a new electric city car introduced in China in 2023, was designed to support a solid-state battery, and it initially sounded like it was going to launch with it. However, the finished production car has two available battery packs, but neither is solid-state.

Mercedes-Benz equipped a few dozen [eCitaro electric city buses](#) destined for the German city of Bremen with solid-state battery packs in 2021 and 2022. They feature 441 kWh lithium polymer batteries with a solid electrolyte produced by Blue Solutions in France. These buses are still in use in Bremen today, and Mercedes notes that even though it still offers a solid-state eCitaro, it's seen more demand for its new generation NMC batteries.

The time frame for solid-state battery rollout is unclear, but there should be a handful of commercially available models by this decade's end. The process of solid-state adoption will be spurred by potential breakthroughs that we can't anticipate. There's also a chance that the constant incremental improvements and lowering of costs brought to liquid electrolyte batteries will keep them relevant even once a viable solid-state battery solution hits the market. It will be a question of cost more than anything else.

Factorial's New Manufacturing Facility Will Feature Largest Solid-State Battery Line In US

Factorial has joint venture agreements with Hyundai, Mercedes-Benz, and Stellantis.

Factorial, a U.S.-based startup that's working on a more cost-effective way of building solid-state batteries for electric vehicles, is opening a new facility in the Boston suburb of Methuen, Massachusetts today.

With backing from names like [Mercedes-Benz](#), [Stellantis](#), and [Hyundai Motor Company](#), the American company developed a proprietary, quasi-solid electrolyte dubbed Factorial Electrolyte System Technology (FEST) that can be integrated into existing lithium-ion battery manufacturing equipment, lowering production costs.

The startup's new facility will initially house a cathode coating line, with plans of expanding the location so that it can accommodate the largest solid-state battery assembly line in the U.S., with an annual capacity of 200 megawatt-hours, but a timeline for this expansion has not been published.

"Factorial continues to drive the battery industry forward and this milestone is no exception," said Joe Taylor, Executive Chairman of Factorial and Former Chairman and CEO of Panasonic Corporation of North America. "Automaker demand for American-made batteries is high to produce electric or hybrid vehicles that qualify for incentives. Our facility will manufacture automotive-sized solid-state batteries at pre-production speed and volume, illuminating a clear path to mass production and reaching economies of scale."

Compared to liquid-based lithium-ion batteries, solid- or quasi-solid-state batteries have the upper hand when it comes to energy density and [the risk of catching on fire](#). This means that a solid-state battery that has the same volume as a lithium-ion battery will typically have a higher capacity, enabling the EV it's fitted in to travel a longer distance.

Solid-state batteries also have the potential to be recharged at much higher rates compared to their liquid-based counterparts, making top-ups faster and journeys less stressful – if you can find a fast enough DC charger, that is.

Factorial's latest milestone is [its 100+ amp-hours cell](#), which was unveiled back in January during the Consumer Electronics Show 2023 in Las Vegas, where Stellantis CEO Carlos Tavares said that by 2026, the solid-state battery developed with Factorial [may](#)

deliver up to 30 percent higher energy density than conventional lithium-ion, while the next-generation of cells will push the density difference to 50 percent.

It's worth noting that the American startup isn't the only company out there that's working on more energy-dense batteries, with [QuantumScape](#), [Nissan](#), and [Toyota](#) among the names that are preparing something similar.

[Toyota](#) recently signed a memorandum of understanding with Idemitsu, which is primarily a petroleum company, to make its 621-mile solid-state batteries a reality and bring them to market in 2027 or 2028.

‘Game Changer’: Honda Solid-State EVs With 620 Miles Of Range Coming This Decade

© insideEvs.com Copyright



‘Game Changer’: Honda Solid-State EVs With 620 Miles Of Range Coming This Decade© insideEvs.com Copyright

Honda claims its future EVs will even go as far as 776 miles on a full charge after 2040. There is one big issue, though.

- Honda is working on solid-state batteries that will give its future EVs impressive driving ranges.
- By the end of the decade, Honda believes its electric cars will be able to drive 620 miles on a full charge.
- From 2040, the driving range is expected to increase to 776 miles.

Honda is kicking its solid-state battery efforts into high gear. The Japanese automaker claims the first electric vehicles fitted with its latest-gen packs would be capable of driving up to 620 miles on a full charge by the end of this decade. That's roughly double the range of today's mass-market EVs.

Besides making range anxiety a non-issue, the new solid-state batteries developed by Honda will be 50% smaller, 35% lighter and 25% cheaper to manufacture than current liquid-based lithium-ion cells. The solid electrolyte cells also promise to be much safer than what is readily available on the market today, as well as accept much higher charging speeds.

After 2040, the goals are even more ambitious. That range figure will be pushed even further to 776 miles, while the size, weight and cost will be even smaller.

The carmaker's executives laid all of this out during [a briefing late last month in Japan](#). The presentation came a week after Honda announced it built [a pilot production facility](#) where it will try to figure out how to make solid-state batteries sustainably and at a mass scale. Test production will begin next month.

It all sounds excellent, and it's undeniable that progress will be made, but Honda execs didn't hold back on significant roadblocks that still lie ahead. The biggest issue is that the prototype battery cells the automaker is experimenting with are tiny and can't be used in any vehicle—100 times too small, in fact.

"That's why we have created the pilot line to identify and deal with any issues in terms of size and mass production as soon as possible," said Takeshi Ueda, chief engineer of innovative research excellence at Honda R&D. "We have to make our prototype battery 100 times bigger. We are working on how to bring them to the mass production phase."

Other issues are related to the production process. The ceramic separators can crack and dendrites can form in the putty-like electrolyte which can lead to a short-circuit. There's also a climate control problem—the humidity in the facility has to be low, which usually means huge equipment that needs massive amounts of energy.

But Honda seems confident it can surpass these hurdles. For pressing the electrolyte in an even and ultracompact layer, it chose a roll-pressing technique that it says achieves thin films at fast speeds. The electrolyte slurry will be made using a continuous mixing method, which is allegedly three times faster than the batch process mixing used for conventional lithium-ion cells. To keep the humidity low, Honda chose to encapsulate each production process in its own climate-controlled area, which should help keep energy costs down because there's no need to warm or cool a vast volume of air in a single room.

"Our all-solid-state battery will be a game changer in this EV era," said Keiji Otsu, president of Honda R&D Co.

Honda is just one of the big players trying to turn the solid-state battery dream into reality. [Toyota](#), [Nissan](#), [Stellantis](#), [BMW](#) and [Volkswagen](#) all work toward the same goal, either on their own or through partnerships with third-party companies.

The Dodge Charger Daytona Is Getting Solid-State Batteries

Stellantis is incorporating Factorial's solid-state cells into a demonstration fleet.

- Stellantis is putting Factorial's quasi-solid-state batteries in the Dodge Charger Daytona EV.
- A demonstration fleet will hit the streets by 2026.

The promise of solid-state batteries in electric vehicles is getting a bit long in the tooth, but it's undeniable that progress is being made. Case in point: [Stellantis](#) will launch a demonstration fleet of [Dodge Charger Daytona](#) electric muscle cars fitted with Factorial's quasi-solid-state cells that are lighter and pack more energy than your average liquid anode cells.

The fleet will hit the streets by 2026, but we don't know how many cars will get the solid-state batteries that promise to be much safer, provide more driving range and charge faster compared to conventional lithium-ion cells. Stellantis also didn't provide a timeline for when people will get the chance to buy EVs with solid-state batteries.

[Stellantis](#), as well as [Mercedes-Benz](#) and [Hyundai Motor Group](#), have invested hundreds of millions of dollars in Factorial's solid-state battery tech. The startup claims its proprietary Factorial Electrolyte System Technology (FEST) can be incorporated into existing lithium-ion cell factories, thus reducing upfront manufacturing costs. The U.S.-based battery developer already has [the country's largest solid-state battery line](#) in the Boston suburb of Methuen, Massachusetts. When it becomes fully operational, it will churn out 200 megawatt-hours worth of batteries every year.

In the upcoming Dodge Charger demonstration EVs, the cells have an energy density of over 390 watt-hours/kilogram, which is superior to the roughly 200 to 300 Wh/kg offered by liquid-anode lithium-ion cells commercially available right now.

"This demonstration fleet is an important milestone in our partnership with Factorial," said Ned Curic, Stellantis' Chief Engineering and Technology Officer. "By integrating Factorial's innovative battery solution into the STLA Large platform, we are validating its potential to enhance our electric vehicle lineup, ensuring customers benefit from improved performance, longer driving ranges and faster charging times in the coming years."

The same STLA Large platform that underpins the Dodge Charger Daytona will be used by [Jeep](#), Alfa Romeo, [Chrysler](#) and [Maserati](#), so we could see solid-state battery-powered EVs from these brands soon, too. The main holdup for the wide adoption of this type of cell has so far been pinned on the cumbersome production ramp-up. Usually, solid-state cell factories need to be built from the ground up, but with Factorial's approach, the production lines of liquid- or gel-based lithium-ion cell factories can just be upgraded, so things can move faster. Let's just hope they move fast enough because the promise of cheaper, longer-range and faster-charging solid-state EVs has been around for at least a decade.

Future Mercedes-Benz EVs May Get Solid-State Batteries With 80% More Range

American battery company Factorial said its new solid-state battery can improve EV range and charging speeds while reducing fire risks.

- Massachusetts-based Factorial has a new solid-state battery named Solstice.
- Factorial is backed by Mercedes-Benz, which led a \$200 million funding round in the company in 2022.
- Mercedes-Benz is already working on bringing these batteries to market by the end of the decade.

Solid-state batteries are considered the next big thing in battery technology. Several automakers are already working with battery companies to develop solid-state cells, hoping to commercialize them in the future to eliminate range anxiety, improve battery safety and increase charging speeds.

One of the automakers investing in the tech is [Mercedes-Benz](#). The German automaker entered a joint development agreement with Massachusetts-based Factorial Energy to develop next-generation batteries in 2021. Mercedes also led a \$200 million funding round in 2022 and today Factorial announced a new solid-state battery named Solstice.

Get the best news, reviews, columns, and more delivered straight to your inbox.

Sign up For more information, read our

[Privacy Policy](#) and [Terms of Use](#).

Factorial said the new battery has an energy density of 450-watt hours per kilogram. Tesla's 4680 nickel cobalt manganese cells installed on the [Model Y](#) have an [estimated energy density](#) of about 272-296 Wh/kg. The American battery start-up said this can potentially extend the range of an EV by 80% while also reducing the weight of the battery pack.

Solid-state batteries basically use a solid electrolyte instead of the liquid or gel electrolytes found in traditional lithium-ion batteries. Key benefits include a higher energy density and far less flammability. Plus, they're faster charging. But so far, they have proven expensive to produce and no one has really figured out scalability. Factorial said this battery uses a proprietary sulfide-based electrolyte that aims to have a high safety rating and operating temperatures of up to 90 degrees Celsius (194F). It also said there's potential to reduce cooling needs and reduce costs. It also incorporates a "dry coating" process that reduces the environmental impact of producing these batteries.

The announcement states that Mercedes-Benz is already working on integrating these batteries into its future EVs. Factorial would be Mercedes' second solid-state battery partner after it announced in 2022 that it was investing millions of dollars in Taiwanese solid-state battery maker [ProLogium](#).

With that, the German automaker joins a growing list of brands investing in this tech, including [Toyota](#) which is developing solid-state batteries that can deliver over [600 miles of range starting in 2026](#).

Toyota's Solid-State Battery Production Plans Approved By Japan's Government

The plan states that Toyota will begin solid-state battery production in 2026, although the initial ramp-up will be slow.

Toyota is expected to be one of the world's first car manufacturers to launch a passenger vehicle powered by solid-state batteries. The company has been talking about its solid-state goals for years, but now its plans to start building cars with this battery tech have been validated by the Japanese Ministry of Economy, Trade and Industry, and the official start of production is set for sometime in 2026.

[Initial production will be very limited](#) but it will be ramped up through 2027 and 2028, although there could still be setbacks that postpone it again. However, actual mass production is planned for "2030 and beyond," according to a post on [Toyota Times](#).

In a recent press release published by [Toyota](#), the manufacturer says it will begin solid-state battery production "starting from 2026" and that this will be "gradually implemented." With its next-generation performance battery (which will be built by two third parties for Toyota), it wants to reach an annual production target of 9 gigawatt-hours, although this combined figure will be achieved over time.

The plan is to build both the solid-state and new high-performance batteries in Japan, although it notes that it "is an equipment-intensive industry requiring large-scale investments in significant facilities. To maintain and enhance manufacturing capabilities and technologies within Japan's battery industry, which includes equipment industries and material manufacturers, government support is provided."

[These new solid-state batteries from Toyota](#) promise much quicker charging times (flat to full in around 10 minutes) and up to 621 miles (1,000 km) of WLTP range at first, which

will later be upgraded to 750 miles. The manufacturer initially announced that it was going to launch a solid-state-powered vehicle in 2020, but this never materialized, and the manufacturer said it was holding back and waiting for a breakthrough to make production feasible.

It [announced a breakthrough](#) in June of 2023, which it said increased the theoretical range provided by these batteries by 20% to over 745 miles. There were also some previous reports that Toyota's first solid-state production car [was going to be a hybrid](#), not a full EV. This makes sense since an EV-sized solid-state battery pack would drive up the vehicle's cost considerably, while a hybrid's smaller pack wouldn't affect the vehicle's total cost as much.

Toyota isn't the only automaker with plans to put solid-state batteries in cars to reap [all their benefits](#). SAIC-owned MG says it will launch its first solid-state-powered production vehicle in 2025. Another SAIC brand, IM Motor, has already revealed the L6, which has a 133 kWh semi-solid-state battery that promises to deliver a range of up to 673 on the Chinese CLTC test cycle. Charging it for just 12 minutes adds 249 miles of range.

Nissan To Launch EV With Solid-State Batteries In Five Years

The Japanese carmaker is on track to have its solid-state battery factory operational by 2025.

Nissan says it's in a "class-leading position" to make the first batch of liquid-free, lower-cost solid-state batteries in 2025, with a brand new electric vehicle powered by said batteries slated for production in 2028.

The timeline comes from the company's senior vice president for research and development in Europe, David Moss, who spoke with UK-based publication *Autocar* about the Japanese brand's advancements in solid-state technology.

[Nissan](#) initially announced its involvement in the development of solid-state batteries for EVs [back in 2021](#), when it said it will build a pilot facility where prototype cells would be made. [One year later](#), prototype development was underway at the Nissan Research Center in Kanagawa Prefecture, Japan.

Now, the marque's exec in Europe basically confirms the timeline for *Autocar*, saying that Nissan is on track to have pilot solid-state batteries in limited

production by 2025, completed engineering in the initial technology by 2026, and the first mass-produced EV with the technology by 2028.

Additionally, Moss says Nissan is taking steps to further develop current lithium-ion battery technology, aiming to release the next generation of cells within the next couple of years, then in 2028 a cobalt-free one, which would reduce costs by as much as 65%.

In regards to solid-state cells, their advantages are obvious over currently-available batteries, starting with the tripling of charging speeds, getting close to a constant 400 kilowatts no matter the temperature, and continuing with double the energy density in the same physical space, all at half the cost. Nissan previously stated that its goal is to achieve a cost of \$75 per kWh at the pack level by the fiscal year 2028 and \$65 per kWh thereafter.

Gallery: Nissan Max-Out Convertible Concept

Working in collaboration with scientists from the University of Oxford, Nissan engineers in Japan managed to go from small button-sized cells to larger, 10-centimeter square cells in the current stage of development, with the final cells' size to be comparable to that of a laptop's dimensions.

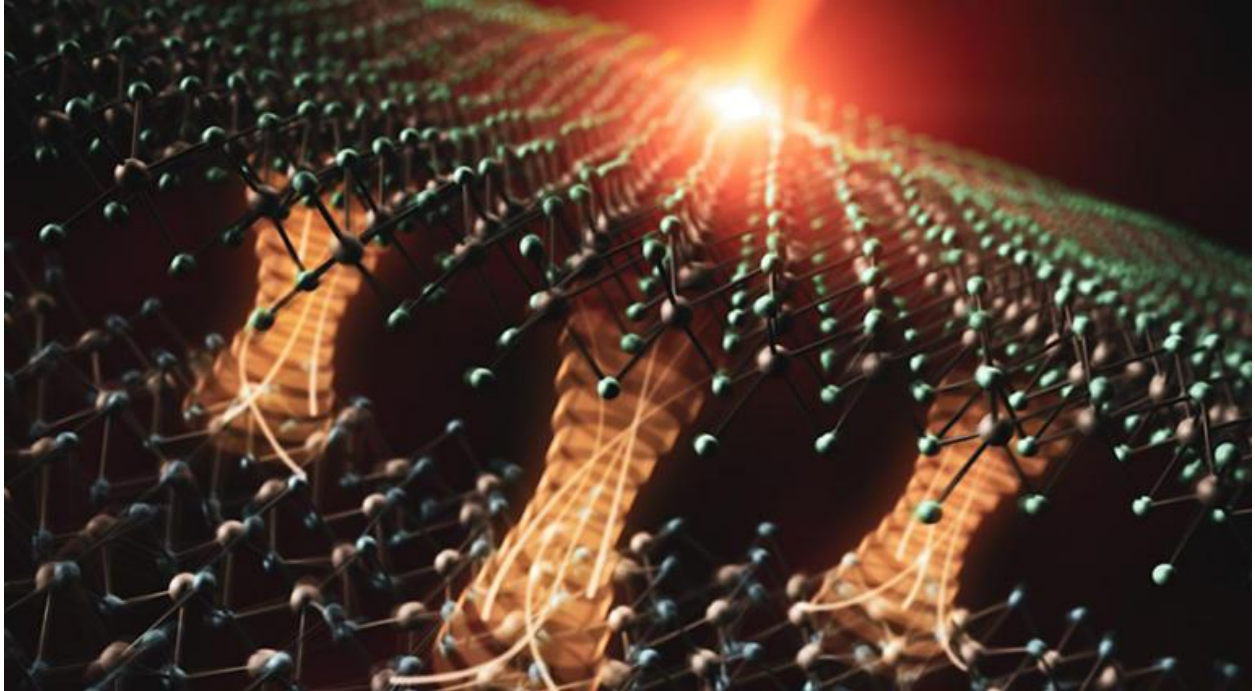
Moss added that the Japanese brand wants to completely remove the liquid elements from the battery, saying that this would greatly improve the efficiency in storage and power transfer.

“Can you delete the liquid electrolyte out of the battery? This is where we think we’re leading,” said Moss. “Some solid-state batteries still have the liquid electrolytes, and this is an issue, as that liquid boils. The efficiency of that energy in storage and transfer and the power you put into it will be impacted.”

Achieving all these goals ultimately means that future electric vehicles will be lighter, have more range, and be able to charge much more quickly, all while costing less (at least the batteries).

Nissan isn't the only company out there dedicated to bringing solid-state batteries to the mass market, with [StoreDot](#), [SolidPower](#), [Factorial](#), [QuantumScape](#), and others working on their versions of the technology.

US 'ion superhighway' sets 10x speed record for faster batteries, biosensors



US 'ion superhighway' sets 10x speed record for faster batteries, biosensors

Researchers at Washington State University and Lawrence Berkeley National Laboratory have made a big breakthrough.

They have detailed the creation of a nanoscale structure that enables ions to move at speeds ten times faster than previously observed in mixed organic ion-electronic conductors.

This could lead to massive achievements in several fields ranging from battery technology to brain-computer interfaces.

"A speed record has been broken using nanoscience, which could lead to a host of new advances, including improved battery charging, biosensing, soft robotics and neuromorphic computing," said the researchers in a press release.

Focus on mixed organic ion-electronic conductors

The research focuses on mixed organic ion-electronic conductors, a class of materials that combine the unique properties of both ionic and [electronic conductivity](#).

“These types of conductors hold a lot of potential because they allow movement of both ions and electrons at once, which is critical for battery charging and energy storage,” added the press release.

However, progress in this field has been hampered by the relatively slow movement of ions within these conductors. Because these ions move in a coordinated manner, it also slows the electrical current.

“We found that the ions that were flowing all right in the conductor, but they had to go through this matrix, like a rat’s nest of pipelines for electrons to flow. That was slowing down the ions,” explained Brian Collins, WSU physicist and senior author of the study.

Taking inspiration from biological systems

To address this challenge, the researchers drew inspiration from biological systems, which have evolved highly efficient mechanisms for ion transport.

By mimicking the structure of ion channels found in cell membranes, they engineered a nanometer-sized channel lined with hydrophilic (water-attracting) molecules.

Notably, ions are typically dissolved in [water](#), forming an electrolyte solution. Therefore, the hydrophilic lining of the channel could attract the ions, effectively creating a dedicated “superhighway” for their movement.

“The ions then moved very quickly through the channel — at speeds more than ten times faster than they would through water alone,” [asserted](#) the researchers.

“The movement of ions represented a new world record for ion speed in any material to be documented.”

The researchers also demonstrated the ability to dynamically control the flow of ions within these nanochannels. By using chemical reactions to switch the channel between hydrophilic and hydrophobic (water-repelling) states, they can effectively open and close the "ion superhighway."

"Conversely, when the researchers lined the channel with hydrophobic, water-repelling molecules, ions stayed away and were forced to travel through the slower 'rat's nest' instead," remarked the press release.

Implications of this discovery are substantial

Faster ion transport could lead to significant improvements in battery technology, enabling faster charging times and increased energy storage capacity.

This is crucial for the development of next-generation batteries for electric vehicles and portable electronics.

"The next step is really to learn all the fundamental mechanisms of how to control this ion movement and bring this new phenomenon to technology in a variety of ways," concluded Collins.

By integrating these "ion superhighways" into sensors, it may be possible to detect minute changes in the environment, such as pollutants or biological molecules.

This technology could also be used to develop more sophisticated brain-computer interfaces, enabling more seamless communication between the brain and electronic devices.

Battery Prices Down So Sharply That EVs Could Reach Gas Car Prices By 2026



Lithium-ion battery prices witnessed a rapid fall in 2024. But something might stop this cascade.

"I don't like electronic cars," said a middle-aged woman sitting next to me on a recent flight out of New York. "They're more expensive and don't go too far," she added before casually revealing that both her sons in Texas drive Teslas.

I just nodded. But this was one of the several dozen conversations I've had with strangers who shared their feelings about EVs. Educating the masses will be a massive undertaking for everyone involved in this transition. And while I didn't engage with her, I'm hoping she's reading [InsideEVs](#) this morning because lithium prices are falling faster than expected, as per a new report, speeding up the timeline for EVs to reach price parity with gas cars.

Welcome back to [Critical Materials](#), your daily round-up of news and events shaping the future of road transport. We're also discussing loyalty among EV owners and the upcoming Stellantis-CATL battery plant in Spain.

30%: Battery Prices Haven't Tumbled Like This In Years



CATL Shenxing fast-charging LFP battery announcement© InsideEVs

EV battery prices are inextricably linked to costs of raw materials like lithium, a key ingredient in a cell, along with nickel, cobalt, graphite, manganese and more. While several studies have previously forecast battery prices to plummet over time, a new report from research firm BloombergNEF states that prices might be falling faster than expected, accelerating the industry's quest for EVs to cost as much as gas cars on average by 2026.

This year, especially, was huge for the battery industry, with prices dropping 20% to \$115 per kilowatt-hour. Factors like lower component prices, cell overproduction and burgeoning chemistries like lithium-iron-phosphate drove the price drop this year, as per the report.

Here's more from [BloombergNEF](#):

The faster-than-expected decline signals that prices for electric vehicles could fall to similar levels to internal combustion engine vehicles as soon as in 2026, when average pricing is expected to fall below \$100/kWh, the benchmark often referenced as the point of price parity.

"China alone is expected to produce enough battery cells to meet 92% of total global demand of 1.2 terawatt-hours for EV and stationary storage segments in 2024," the report said. "This exerted downward pressure on battery prices. Smaller manufacturers are being challenged by their larger peers, pressured to lower cell prices and cut margins for market share." Whether this downward trend continues over the next few years remains an open question.

Under the Inflation Reduction Act, the Advanced Manufacturing Production Tax Credit (Section 45X) has massively subsidized battery costs. But its future now hangs in the balance. It's uncertain if President-elect Donald Trump will also repeal 45X alongside the consumer tax credit (30D) of up to \$7,500.

I'm inclined to think Trump won't dismantle the entirety of the IRA. The law's hundreds of billions in incentives have created thousands of well-paying American jobs and made North America the [fastest-growing battery manufacturing region](#) in the world.

Curtailing this ["white gold" rush](#) would be like giving away a lucrative inheritance just to appease a few friends and donors in oil and gas. It wouldn't just stunt the auto industry's growth, but also give China an even greater lead despite being so close to achieving price parity with polluting gas cars.

60%: Buyers Are Loyal Towards EVs Globally

According to a [study](#) by the Global EV Alliance (GEVA), an auto industry non-profit, the vast majority of car buyers who go electric aren't looking back.

Of the respondents surveyed, 92% said they would repurchase fully electric models, 4% said they would opt for plug-in hybrids and about 1% said they would return to gas cars. Nearly all of them said they were satisfied being EV

drivers, thanks largely to two leading factors: lower operating costs and climate concerns.

"This is a remarkably high number and the results confirm that drivers love the EV experience and EVs are here to stay," said Joel Levin, chair of GEVA and Director of Plug In America. Lower operating costs topped climate concerns as the leading reason to buy EVs, which signals that buyers have started appreciating the practicality and logic of EVs.

Even though 72% of the respondents had home charging access, they also cited public charger reliability, uptime and long charging times as the key disadvantages.

We've seen plenty of EV loyalty studies in the past. A recent [McKinsey study](#) said that 46% of U.S. and 29% of global EV buyers returned to gas cars. Another J.D. Power study also had similar results. A separate [S&P Mobility study](#) said that nearly 68% of Tesla buyers returned to the brand.

The GEVA survey had 23,254 respondents from 18 countries including the U.S., U.K., Germany, France, Norway, and India, leaving China out.

Cross-Atlantic conglomerate Stellantis, which has 14 brands under its umbrella including Jeep, Ram and Dodge, has teamed up with Chinese battery maker Contemporary Amperex Technology Ltd to invest up to \$4.3 billion for a lithium-ion battery plant in Zaragoza, Spain.

Stellantis is in crisis mode. Its sales are dropping and profits are shrinking due to increased competition from Chinese automakers in Europe, a challenging landscape for electrification altogether.

Now the automaker is turning to the world's largest battery maker to catch up.

The 50-50 joint venture with CATL will focus on manufacturing lithium-iron-phosphate (LFP) batteries. The JV is targeting the start of production by the end of 2026 and will supply packs for affordable crossovers and SUVs with an "intermediate range."

However, reaching its maximum capacity of 50 gigawatt-hours comes with a big asterisk. Scaling up would depend on support from the Spanish government and the European Union, Stellantis said.

100%: Would You Buy An EV Again?

EV loyalty surveys are all over the place. No shocker there since adoption varies so much by region. But we want to hear from you: If you've gone electric, are you in for life? Or would you consider switching back to gas or hybrid? Drop your thoughts in the comments. We do read them quite seriously.

EV batteries could last 40% longer than expected, Stanford study stuns

Researchers at Stanford University's Precourt Institute for Energy and SLAC

National Laboratory have shown that an average electric vehicle (EV) battery could last 40 percent longer than what standard laboratory tests forecast.

This means EV owners may not have to buy a new battery pack or replace their car for an additional few years, delivering a higher return on their decision to go electric.

To end tail-pipe emissions, countries are promoting the adoption and use of EVs. The 600-mile ranges for EVs today have addressed range anxiety among potential owners. Still, worries about the health of the battery packs remain.

Battery costs may have reduced to a tenth of what they were over a decade ago, but they still account for a third of the price of a new EV. In such a scenario, EV owners dread when their battery pack may end its life cycle and there emerges a need for complete replacement.

The joint study by Stanford and SLAC researchers shows that the day will arrive much later than EV manufacturers forecast, which applies even to the roughest EV owners.

Testing the EV batteries in the wrong way

Standard laboratory tests for batteries check new battery designs by discharging them constantly and recharging them fully. They repeat this exercise over multiple cycles to determine if the battery design is reliable and has an acceptable [life expectancy](#).

In the real world, though, this does not happen. A battery pack on an EV runs to power the car in the high traffic of the cities, on the highways, at frequent traffic lights, or staying parked for long hours at home or office parking, none of which are factored for in battery tests.

"We've not been testing EV batteries the right way," said Simona Onori, an associate professor of energy science and engineering at the Stanford Doerr School of Sustainability who was involved in this work.

"To our surprise, real driving with frequent acceleration, braking that [charges the batteries](#) a bit, stopping to pop into a store, and letting the batteries rest for hours at a time helps batteries last longer than we had thought based on industry-standard lab tests."



Representational stock image of an EV battery. Image credit: South_agency/iStock

What did the team study?

To represent battery usage scenarios more accurately, the research team designed four types of EV discharge profiles, including a consistent and dynamic discharge setup using real-world driving data.

Over two years, the team tested 92 commercially available lithium-ion batteries and found that the battery life climbed as the profiles reflected more real-world driving behavior.

For instance, the study showed that short and sharp EV acceleration slowed the degradation of batteries, and pressing the pedal hard slows down the battery's aging instead of hastening it, the [press release](#) added.

The researchers also investigated if batteries aged faster when going through charge-discharge cycles continuously, like delivery vehicles or when they were sitting idle for longer durations. They found that the sweet spot for aging was between the two, which is more realistic for EV consumers.

Tweaks to battery management systems from EV manufacturers could help deploy their research in real-world conditions immediately.

The applications of their research extend [beyond](#) EV batteries into energy storage and even powering implants in the human body.

The research findings were published in the journal [Nature Energy](#)

‘Game Changer’: Honda Solid-State EVs With 620 Miles Of Range Coming This Decade

Honda claims its future EVs will even go as far as 776 miles on a full charge after 2040. There is one big issue, though.

- Honda is working on solid-state batteries that will give its future EVs impressive driving ranges.
- By the end of the decade, Honda believes its electric cars will be able to drive 620 miles on a full charge.
- From 2040, the driving range is expected to increase to 776 miles.

[Honda](#) is kicking its solid-state battery efforts into high gear. The Japanese automaker claims the first electric vehicles fitted with its latest-gen packs would be capable of driving up to 620 miles on a full charge by the end of this decade. That's roughly double the range of today's mass-market EVs.

Besides making range anxiety a non-issue, the new solid-state batteries developed by Honda will be 50% smaller, 35% lighter and 25% cheaper to manufacture than current liquid-based lithium-ion cells. The solid electrolyte cells also promise to be much safer than what is readily available on the market today, as well as accept much higher charging speeds.

After 2040, the goals are even more ambitious. That range figure will be pushed even further to 776 miles, while the size, weight and cost will be even smaller.

The carmaker's executives laid all of this out during [a briefing late last month in Japan](#). The presentation came a week after Honda announced it built [a pilot production facility](#) where it will try to figure out how to make solid-state batteries sustainably and at a mass scale. Test production will begin next month.

It all sounds excellent, and it's undeniable that progress will be made, but Honda execs didn't hold back on significant roadblocks that still lie ahead. The biggest issue is that the prototype battery cells the automaker is experimenting with are tiny and can't be used in any vehicle—100 times too small, in fact.

"That's why we have created the pilot line to identify and deal with any issues in terms of size and mass production as soon as possible," said Takeshi Ueda, chief engineer of innovative research excellence at Honda R&D. "We have to make our prototype battery 100 times bigger. We are working on how to bring them to the mass production phase."

Other issues are related to the production process. The ceramic separators can crack and dendrites can form in the putty-like electrolyte which can lead to a short-circuit. There's also a climate control problem—the humidity in the facility has to be low, which usually means huge equipment that needs massive amounts of energy.

But Honda seems confident it can surpass these hurdles. For pressing the electrolyte in an even and ultracompact layer, it chose a roll-pressing technique that it says achieves thin films at fast speeds. The electrolyte slurry will be made using a continuous mixing method, which is allegedly three times faster than the batch process mixing used for conventional lithium-ion cells. To keep the humidity low, Honda chose to encapsulate each production process in its own climate-controlled area, which should help keep energy costs down because there's no need to warm or cool a vast volume of air in a single room.

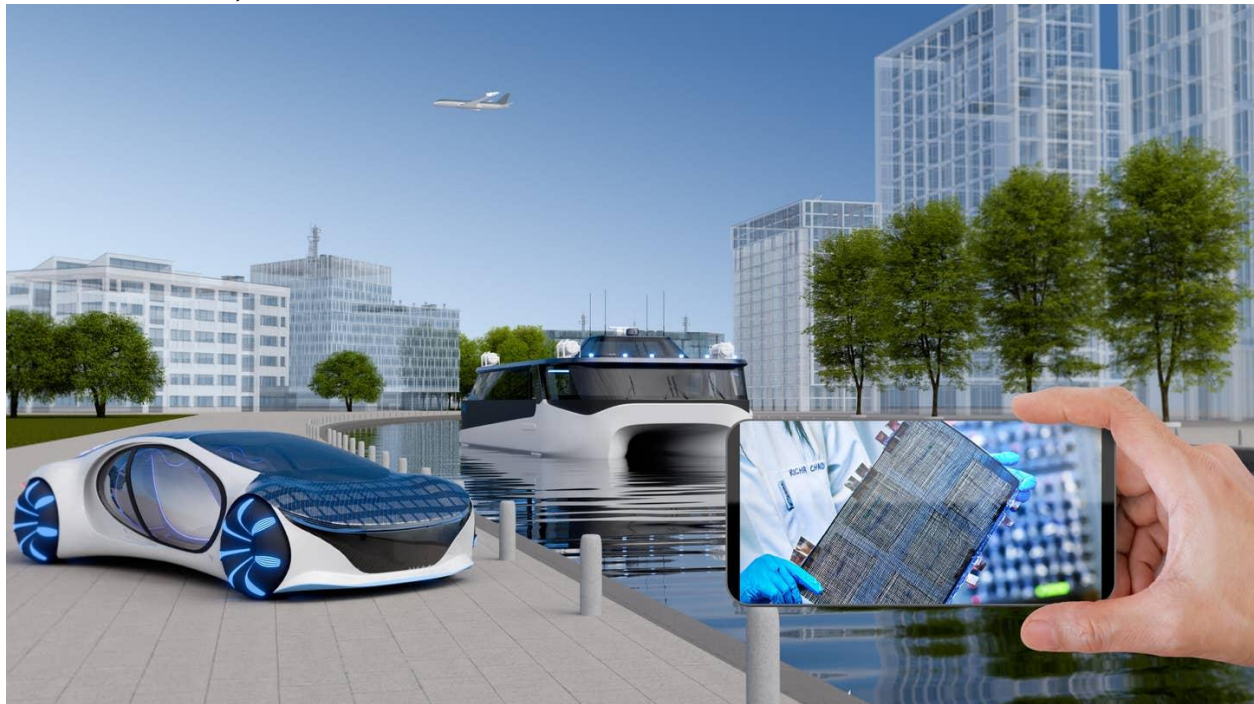
"Our all-solid-state battery will be a game changer in this EV era," said Keiji Otsu, president of Honda R&D Co.

Honda is just one of the big players trying to turn the solid-state battery dream into reality. [Toyota](#), [Nissan](#), [Stellantis](#), [BMW](#) and [Volkswagen](#) all work toward the same goal, either on their own or through partnerships with third-party companies.

World's most powerful battery paves way for light, energy-efficient vehicles

Structural batteries combine energy storage with mechanical strength, revolutionizing electric vehicles, aerospace, and portable electronics

Published Nov 27, 2024 9:07 AM PST



Structural batteries blend energy storage with lightweight design, enabling electric cars to drive farther and devices to become thinner and lighter. (CREDIT: Chalmers University of Technology)

[Share this story](#)

Weight reduction in vehicles and devices directly translates to improved energy efficiency. Traditional [lithium-ion](#) batteries, while powerful, limit the energy density needed for groundbreaking advancements in electric vehicles, aircraft, and portable electronics.

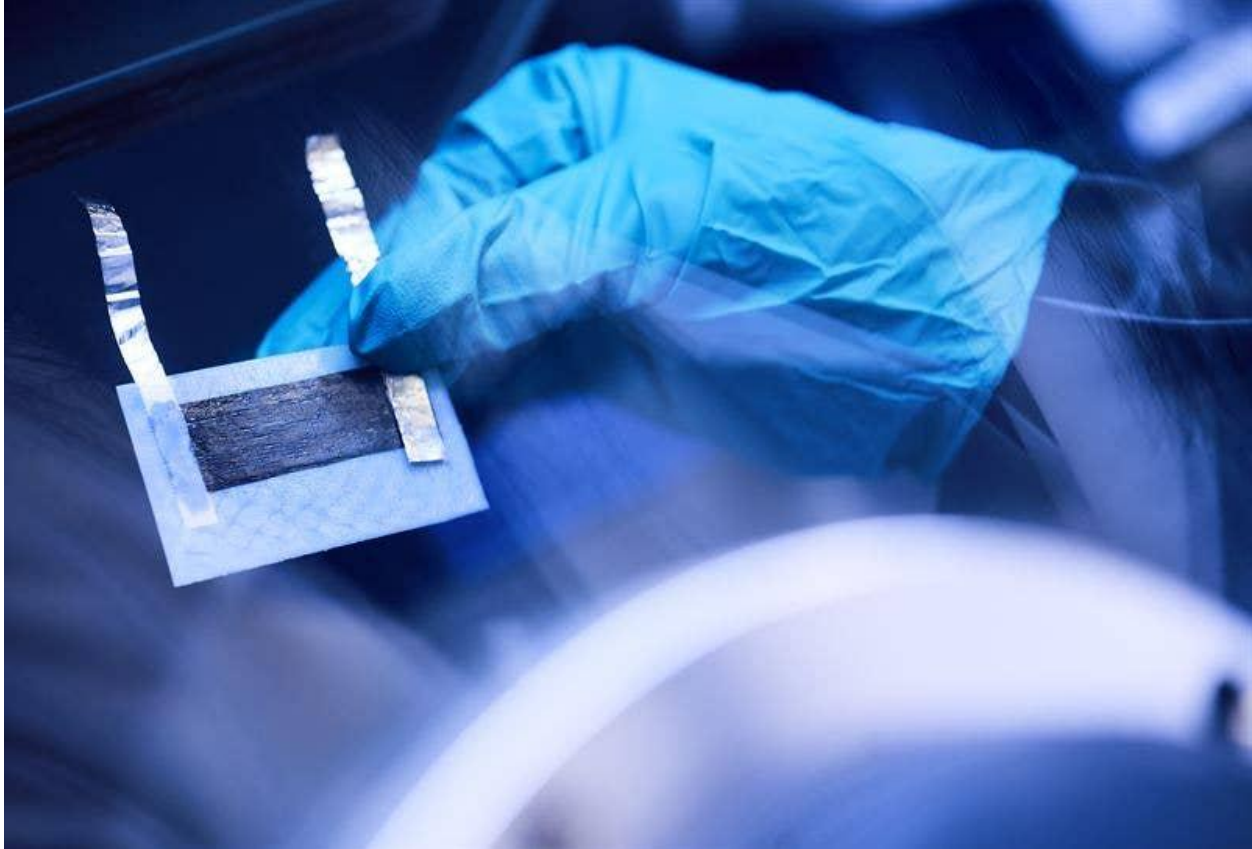
The video player is currently playing an ad.

[Skip Ad](#)

Enter structural batteries—a transformative concept combining energy storage with structural integrity, heralding a new era in multifunctional material science.

The Concept of Structural Batteries

[Structural batteries](#) serve dual purposes: storing energy and bearing mechanical loads. Unlike conventional batteries that only supply energy, these batteries are integrated into the structure of a device or vehicle. By reducing system weight, they enable increased energy efficiency and extended range.



The developed battery concept is based on a composite material and has carbon fibre as both the positive and negative electrodes. (CREDIT: Chalmers University of Technology / Henrik Sandsjö)

For instance, replacing an electric vehicle's roof with a structural battery could cut weight by up to 20%, freeing space for additional batteries and significantly [improving mileage](#).

The potential applications are vast. A structural battery could halve a laptop's weight or make smartphones as thin as a credit card. Electric cars, powered by such batteries, could increase their range by as much as 70%.

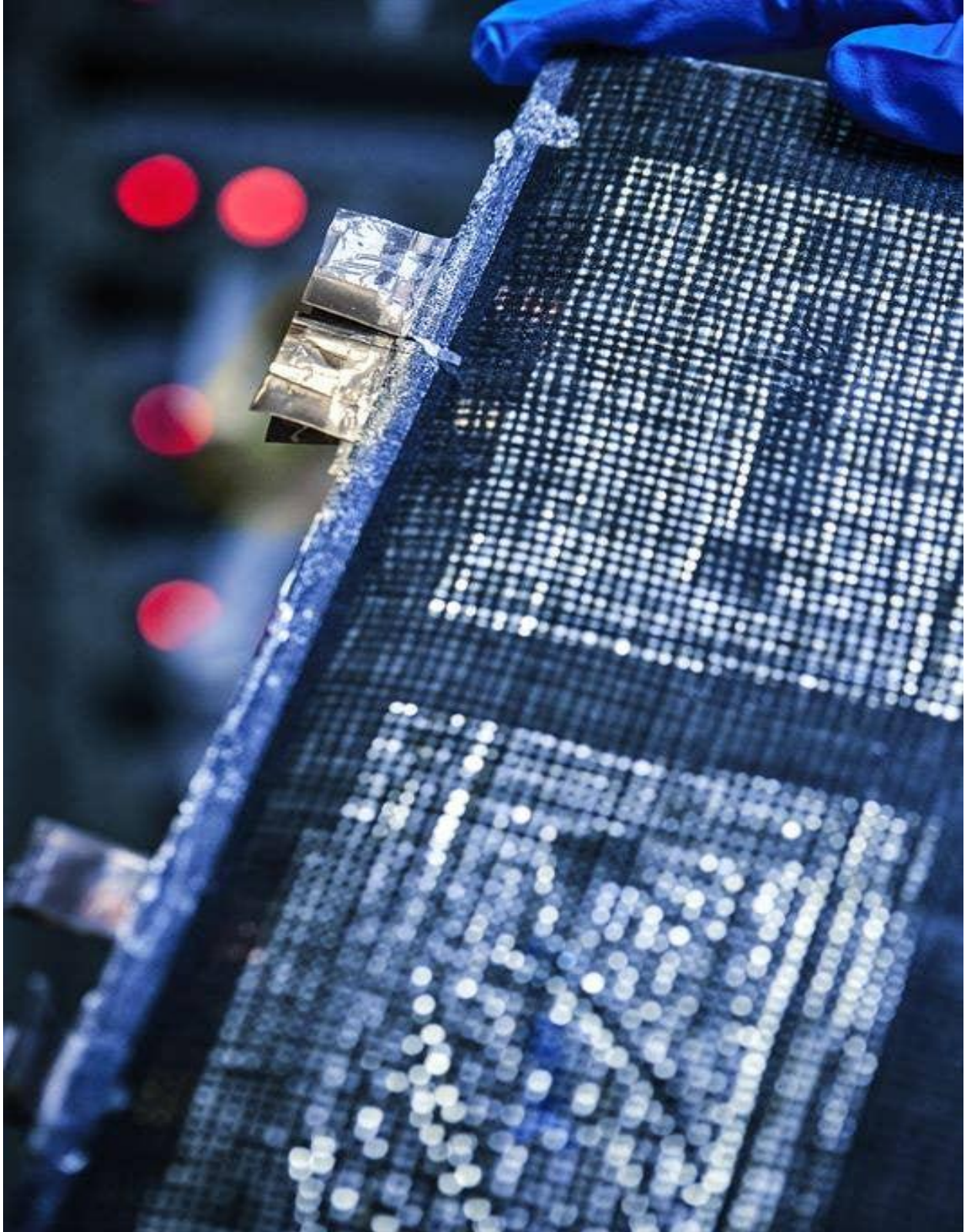
As researcher Richa Chaudhary from [Chalmers University of Technology](#) in Sweden explains, this is akin to a "human skeleton," performing multiple functions simultaneously.

Materials Driving Innovation

Structural batteries rely on advanced materials like intermediate modulus polyacrylonitrile-based carbon fibers (PAN-CF). These fibers strike the optimal balance between mechanical strength and electrochemical properties, allowing them to act as both electrodes and reinforcement structures.

Recent studies reveal promising results when carbon fibers are coated with [lithium iron phosphate](#) (LiFePO₄ or LFP) using electrophoretic deposition. However, initial tests showed poor capacity retention of 47% after 100 cycles due to weak bonding between LFP and carbon fibers.

As LFP nanoparticles detach from the carbon fibers during repeated charging cycles, performance diminishes. By incorporating reduced graphene oxide (rGO) into the design, researchers improved adhesion and achieved a specific capacity of 72 mAh g⁻¹ at a 2C-rate, although this remains below the theoretical potential.



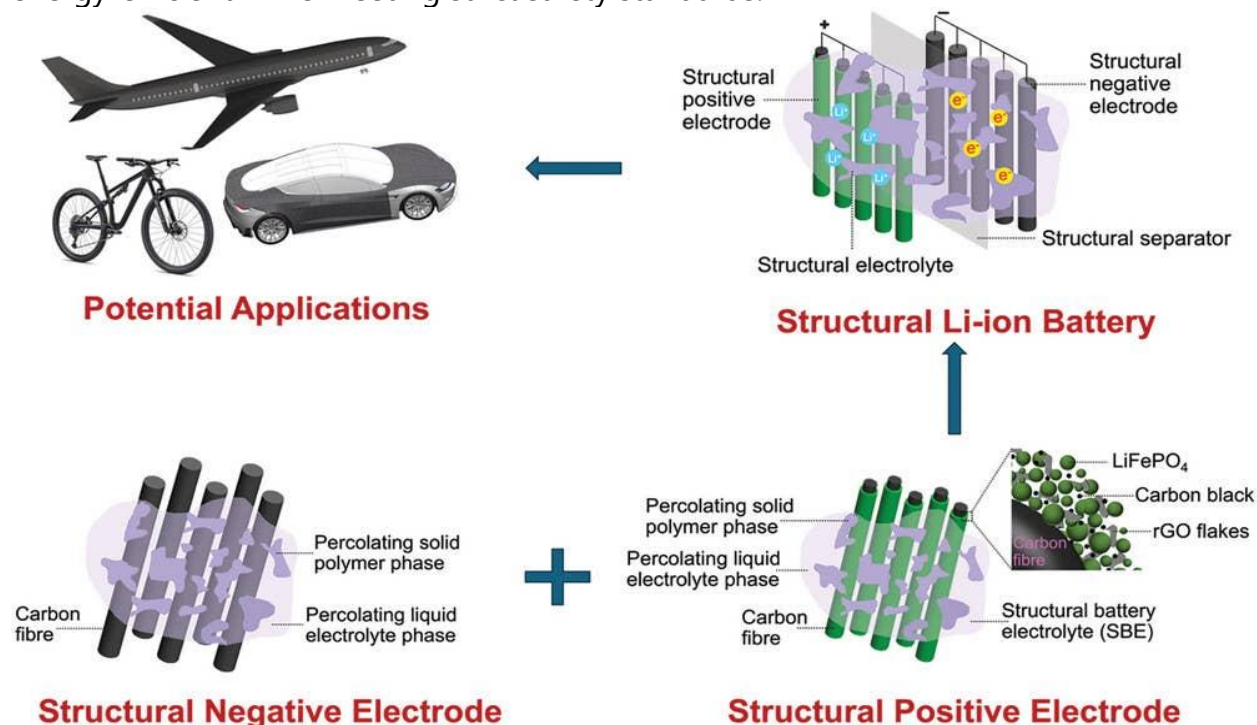
Researchers at Chalmers University of Technology have succeeded in creating a battery made of carbon fibre composite that is as stiff as aluminium and energy-dense enough to be used commercially. (CREDIT: Chalmers University of Technology / Henrik Sandsjö)

Further innovations include using carbon fibers as the anode and combining them with aluminum foil coated in LFP as the cathode. Testing various separators revealed that thinner materials reduced internal resistance, resulting in higher energy densities. For instance, the Whatman GF plain weave separator outperformed thicker alternatives, doubling [energy density](#) from 12 Wh/kg to 24 Wh/kg.

Chalmers University of Technology has been at the forefront of structural battery research. Its groundbreaking work began in 2018, showcasing the ability of stiff carbon fibers to store electrical energy.

The most recent breakthrough saw the creation of a carbon fiber [composite battery](#) boasting an energy density of 30 Wh/kg and an elastic modulus of 70 GPa—comparable to aluminum's stiffness but at a fraction of the weight.

As research leader Leif Asp noted, "Investing in light and energy-efficient vehicles is a matter of course if we are to economize on energy and think about future generations." With these advancements, structural batteries could make electric cars 70% more energy-efficient while meeting strict safety standards.



A detailed roadmap for the development and implementation of All-Fiber Structural Batteries. (CREDIT: Advanced Materials)

Advancing Towards Commercialization

The journey from lab to market is challenging but increasingly promising. The Chalmers team has formed Sinonus AB to accelerate commercialization. Applications in portable electronics, such as credit card-thin smartphones or [ultra-light laptops](#), may be the first to benefit. In the long term, this technology could revolutionize aerospace and automotive industries.

However, significant engineering hurdles remain. For instance, transitioning from liquid to semi-solid electrolytes is critical for achieving higher power densities and improved safety. Semi-solid electrolytes reduce fire risks, an important factor in commercial adoption.

Structural batteries offer several environmental benefits. By eliminating the need for heavy current collectors made of [aluminum](#) or copper, these batteries reduce material usage. Additionally, their design avoids conflict metals like cobalt, frequently associated with traditional lithium-ion batteries.

Richa Chaudhary and Zhenyuan Xia work in the graphene lab at Chalmers. (CREDIT: Chalmers University of Technology / Henrik Sandsjö)

The integration of carbon fibers into both electrodes simplifies the overall structure, further lowering weight. In the anode, the fibers act as reinforcement, current collectors, and active material. In the cathode, they support lithium deposition, eliminating unnecessary components and streamlining production.

Challenges and Future Directions

Despite significant progress, challenges remain. [Liquid electrolytes](#) currently dominate research, limiting the structural battery's full potential. Additionally, using carbon fibers exclusively as negative electrodes or relying on commercial LFP foils for positive electrodes restricts innovation.

Addressing these limitations, Chalmers researchers recently demonstrated an all-carbon-fiber structural battery using pristine carbon fibers as the anode and LFP-coated fibers as the cathode. Embedded in a biphasic solid-liquid electrolyte system, this design achieved an energy density of 33.4 Wh/kg, with an impressive Young's modulus of 38 GPa.

The researchers Zhenyuan Xia, Richa Chaudhary and Leif Asp in the graphene lab at the Department of Industrial and Material Science at Chalmers University of Technology, Sweden. (CREDIT: Chalmers University of Technology / Henrik Sandsjö)

Improvements in manufacturing techniques have further increased energy density to 42 Wh/kg while maintaining mechanical robustness. These advances underline the potential for [structural batteries](#) to integrate seamlessly into large-scale industrial applications, such as cars, planes, and drones.

The global interest in structural batteries is growing, particularly within the automotive and aerospace sectors. These industries stand to benefit the most from lighter, more energy-efficient designs. However, significant investments in research and manufacturing are needed to meet the energy demands of these sectors.

As Professor Asp points out, "One can imagine that credit card-thin mobile phones or laptops that weigh half as much as today are the closest in time." With structural batteries poised to disrupt the status quo, the dream of multifunctional materials driving

our vehicles, powering our gadgets, and reducing environmental impact may soon become reality.

By comparison, people not on the diet saw a 24 percent increase in the biomarker that suggests cancer aggressiveness.

So, those who ate an altered amount of these fats had a better chance at halting cancer progression than those who ate a normal western diet.

Dr Aronson said: 'This significant difference suggests that the dietary changes may help slow cancer growth, potentially delaying or even preventing the need for more aggressive treatments.'

EV batteries could last much longer thanks to new capacitor with 19-times higher energy density that scientists created by mistake

published May 8, 2024

Electric cars and laptop batteries could charge up much faster and last longer thanks to a new structure that can be used to make much better capacitors in the future.



Battery life in phones and EVs could last much longer thanks to new type of capacitor that scientists created by mistake. (Image credit: Viaframe/Getty Images)

A new material structure could revolutionize energy storage by enabling the capacitors in electric vehicles or devices to store energy for much longer, scientists say.

Researchers have developed capacitors from new "heterostructures" with a novel property that reduces the speed at which energy dissipates without affecting their ability to charge quickly.

The new discovery — which the scientists say was unintended and builds off novel electronics work — could be the foundation for better battery life across consumer devices such as laptops or smartphones, as well as more flexibility in grid-scale energy storage. The scientists described their findings in a study published April 18 in the journal [Science](#).

While [batteries](#) can store energy for a long period, they take a long time to charge and discharge electricity. This is where capacitors come in — they store electricity in an electric field that can be quickly charged and discharged for rapid access to power as needed.

Smartphones, for example, generally use power from the battery but get energy from capacitors when power is needed in a short burst — such as for a [camera flash](#). Each smartphone typically has [hundreds of capacitors](#).

Some capacitors use ferroelectric materials to store energy. These materials are naturally polarized, which can be reversed by applying a voltage. When the polarization is reversed, this remains in the capacitor like 'memory', even after the voltage is removed.

Researchers crack new approach to batteries that could help common electrics last nearly 20 times longer between charges (Image credit: ktsimages/Getty Images)

Applying power reverses the polarization of these materials, and they can maintain this polarization even after the power has been removed. However, they generally retain energy poorly over longer periods compared with batteries.

The new structure sits in a physical and chemical balance between conductivity and non-conductivity, letting it more effectively retain energy. By accident, the researchers found that a tiny gap in the core increases the relaxation time — a term used to describe the period over which the capacitor loses charge.

In each of the heterostructures, 2D and 3D materials are layered like pasta sheets in a lasagna at an atomic level, with chemical and non-chemical bonds between each layer. The maximum thickness of the overall structure or is just 30 nanometers – around 30,000 times thinner than a human hair.

Researchers said the technology could deliver energy density up to 19 times higher than current capacitors. The team also reported an efficiency of more than 90%, a standout

result in the field. Comparable efficiency for novel ferroelectric capacitors stands at 86.95%, according to research published in July 2023 in the journal [Materials](#).

"We found that dielectric relaxation time can be modulated or induced by a very small gap in the material structure," said [Sang-Hoon Bae](#), an assistant professor of mechanical engineering and materials science at Washington University, in a [statement](#). "That new physical phenomenon is something we hadn't seen before. It enables us to manipulate dielectric material in such a way that it doesn't polarize and lose charge capability."

If reproduced at scale, the structure could power a shift in the way that we store and access energy because it would allow energy to be accessed very fast on demand without sacrificing the stability of long-term storage. With higher energy densities, next-generation capacitors could enable greater use of fast-charging capacitors for devices that need long-term storage such as electric vehicles. Capacitors could also provide fast, on-demand power for the grid or private industrial uses.

Battery breakthrough extends EV range to over 3,000 miles on a single charge

In the fast-paced world of electric vehicles (EVs), a major breakthrough in [battery technology](#) is set to significantly enhance energy storage capacity. This development arrives at a crucial moment, as the EV industry is experiencing rapid growth, making it an ideal time for such a transformative advancement.

Researchers at [Pohang University of Science & Technology](#) (POSTECH) have introduced a revolutionary technique that can amplify the energy storage capacity of batteries by an astonishing tenfold. This leap forward not only propels battery technology to new heights but also has the potential to reshape the entire landscape of electric vehicles.

Understanding the Role of the Anode in Batteries

The key to understanding battery function lies in the anode, the component responsible for storing power during charging and then releasing it when the battery is in use. In most modern [lithium batteries](#), graphite is the predominant material used for anodes.

However, materials like silicon offer much greater energy [capacity than graphite](#), making them highly desirable for more efficient battery designs. The challenge, however, has always been in stabilizing a battery that uses a silicon anode. Silicon

tends to expand during internal reactions within the battery, which can compromise its stability and safety.

A Breakthrough in Silicon Anode Technology

Professors Soojin Park and Youn Soo Kim of POSTECH, in collaboration with Professor Jaegeon Ryu of Sogang University, have developed a groundbreaking solution to this long-standing issue. They have engineered a special binding material that prevents a high-capacity silicon anode from expanding. The result is a [lithium battery](#) with ten times the capacity of those with graphite anodes.

While POSTECH's achievement is remarkable, they are not the only ones in the global race to revolutionize battery technology. Numerous teams around the world are working on more sustainable and efficient solutions.

For example, a Chinese company has developed an [EV battery](#) that uses sodium, a material that is both affordable and widely available, as a viable alternative to the more expensive lithium.

Meanwhile, NASA is advancing solid-state battery technology, which promises to be both more compact and lightweight compared to traditional lithium batteries. Additionally, another researcher is exploring the creation of biodegradable batteries using crab shells.

The team introduced polyethylene glycol to regulate the physical properties and facilitate Li-ion diffusion, resulting in the thick high-capacity electrode and maximum energy density found in Li-ion batteries. (CREDIT: Wiley)© The Brighter Side of News

Towards a Greener Future

The implications of these advancements in battery technology extend far beyond transportation. Efficient batteries are essential for optimizing cleaner energy sources, such as wind and solar power. Unlike fossil fuels, which can deliver energy on demand, renewable sources like [solar and wind](#) depend on weather conditions.

All-solid-state lithium batteries have emerged as a priority candidate for the next generation of safe and energy-dense energy storage devices surpassing state-of-art lithium-ion batteries. (CREDIT: Wiley)© The Brighter Side of News

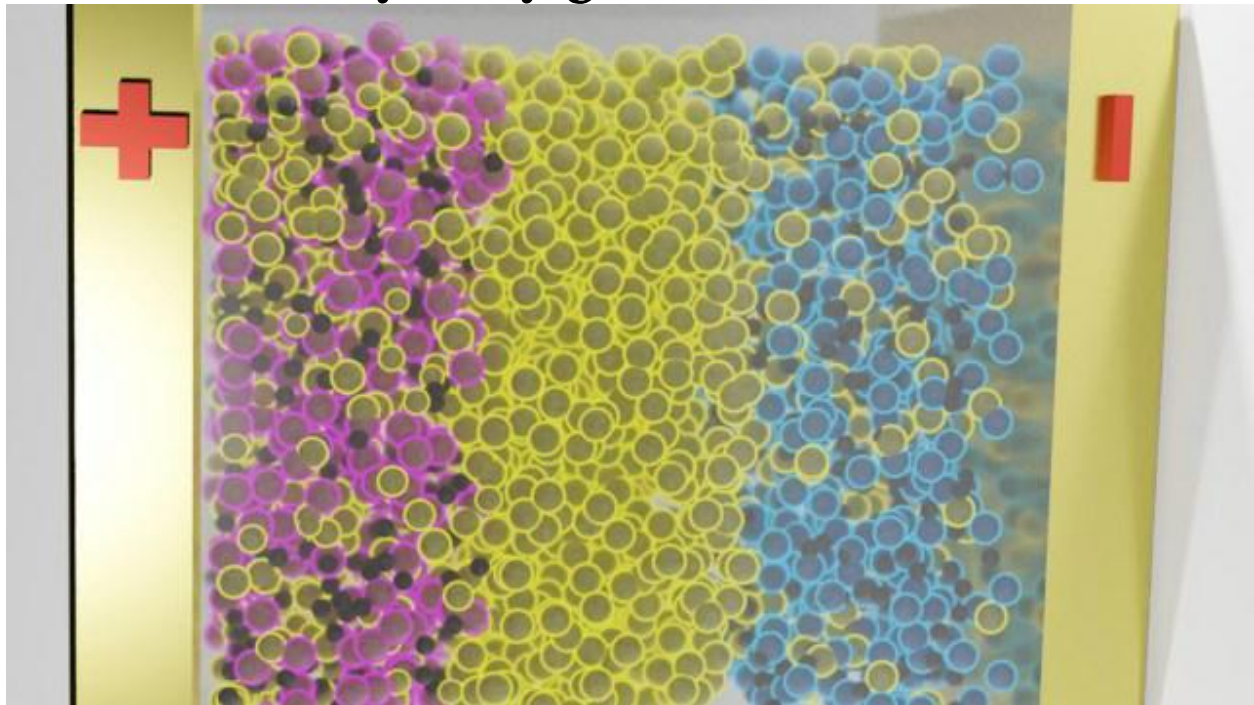
Reflecting on this significant achievement, Professor Park stated on the POSTECH website, "The research holds the potential to significantly increase the energy

density of lithium-ion batteries through the incorporation of high-capacity anode materials, thereby extending the [driving range of electric vehicles](#)."

He also highlighted the transformative potential of silicon-based anodes, noting, "Silicon-based anode materials could potentially increase the driving range at least tenfold."

As the world moves toward a greener future, it is clear that advances in battery technology will play a central role in this transition, driving the shift away from polluting energy sources. With these recent developments, that future seems closer than ever.

Scientists develop battery breakthrough that could ease common concern about EVs: 'One of the industry's key goals'



Scientists develop battery breakthrough that could ease common concern about EVs: 'One of the industry's key goals'

Experts at Canada's McGill University are working to free ions inside of [solid-state](#) power packs.

The work, [described](#) in a university news release, has resulted in a porous ceramic electrolyte that addresses performance-depleting resistance happening where the electrolyte meets electrodes.

When batteries [operate](#), ions move between two electrodes in a substance called electrolyte, which is a liquid in most common power packs used in [electric vehicles](#) and other devices. Solid-state ones, with a hard electrolyte, are considered to be the future. The perks are a light, safe, fast-charging battery with a long lifespan. But production and performance concerns need to be overcome first, [according](#) to Top Speed and [Forbes](#).

McGill's research team discovered their electrolyte frees up ion movement and provides better performance. A dense plate is traditionally used, [per](#) the university summary.

"By using a polymer-filled porous membrane, we can allow lithium ions to move freely and eliminate the interfacial resistance between the solid electrolyte and the electrodes," Professor George Demopoulos, the research lead, [said](#).

The result, he added in the summary, is better battery performance. "This not only improves the battery's performance but also creates a stable interface for high-voltage operation, one of the industry's key goals," Demopoulos added.

Safety is one of the most-publicized wins for solid-state development. While rare, liquid lithium-ion batteries can combust, causing terrible and [well-documented](#) fires. But a Kelley Blue Book [report](#) illuminates the fire issue well, noting studies that show gas-powered cars are more likely to catch fire than EVs.

McGill's team is joined by experts at universities around the world who are working on solid electrolytes. Scientists in South Korea are even [developing](#) a solid-state toolkit that's intended to be a blueprint for production that others can use.

The right mix of materials and a reliable process is crucial to bringing the battery type to wide-scale use. If successful, better packs could help to grow an already flourishing EV market. EV sales hit three million vehicles during the first quarter of the year, a 25% increase over the same time period in 2023. About one-fifth of cars sold worldwide last year were EVs, [per](#) the International Energy Agency.

Valuable [tax breaks](#) remain available, incentivizing buying one stateside. Gas and maintenance savings can also eliminate around [\\$1,500](#) of expenses each year.

That's in addition to reducing thousands of pounds of heat-trapping air pollution, realized when an EV replaces a fossil-burning ride, as [reported](#) by the U.S. Energy Department. Vehicle exhaust is [linked](#) by medical experts to a greater risk for a variety of health problems.

At McGill, the experts think their electrolyte innovation jumps a key hurdle for solid-state batteries, potentially providing a better power source for future EVs.

"This discovery brings us closer to building the next generation of safer and more efficient batteries for [electric vehicles](#)," study first author and doctoral graduate Senhao Wang [said](#) in the summary.

LG develops game-changing micro-technology that could resolve major concern with electric vehicles: 'A tangible research achievement'



LG's patented material could soon become a part of safer packs powering EVs in a growing market.

Household brand LG has developed an [electric vehicle](#) battery component that's a hundred times smaller than the diameter of a human hair.

But don't let the size fool you, as the material can prevent EV fires "like a fuse" by blocking "the reaction path" at the start of battery overheating. The material is an improvement on other solutions because it acts more quickly to stop fires, [according](#) to a news release from the South Korean company.

"This is a tangible research achievement that can be applied to mass production in a short period," LG Chief Technology Officer Lee Jong-gu said in the summary.

At issue are [well-publicized](#) EV battery fires that can be severe. It's important to note that while concerning, EVs are less likely to catch fire than gas-powered cars, as the Boston Globe [reported](#).

But no one will argue against a fireproof power pack, and that's what LG is working to provide.

Fascinatingly, the ultra-thin material can change its molecular structure with battery temperature fluctuations, suppressing the current flow when needed. This prevents dreaded [thermal runaway](#), a short-circuit causing temperatures to heighten uncontrollably to more than 1,800 degrees Fahrenheit, often leading to a fire.

Once the temperature returns to a safe level, the material reverses operation, allowing current to flow again, as described by LG and ScienceDirect.

LG's material performed well during battery impact and [penetration testing](#). The latter analysis is a violent study where a nail is driven into a battery cell to cause a short circuit. The material either prevented a blaze altogether, or snuffed out flames quickly after forming, [per](#) LG's report.

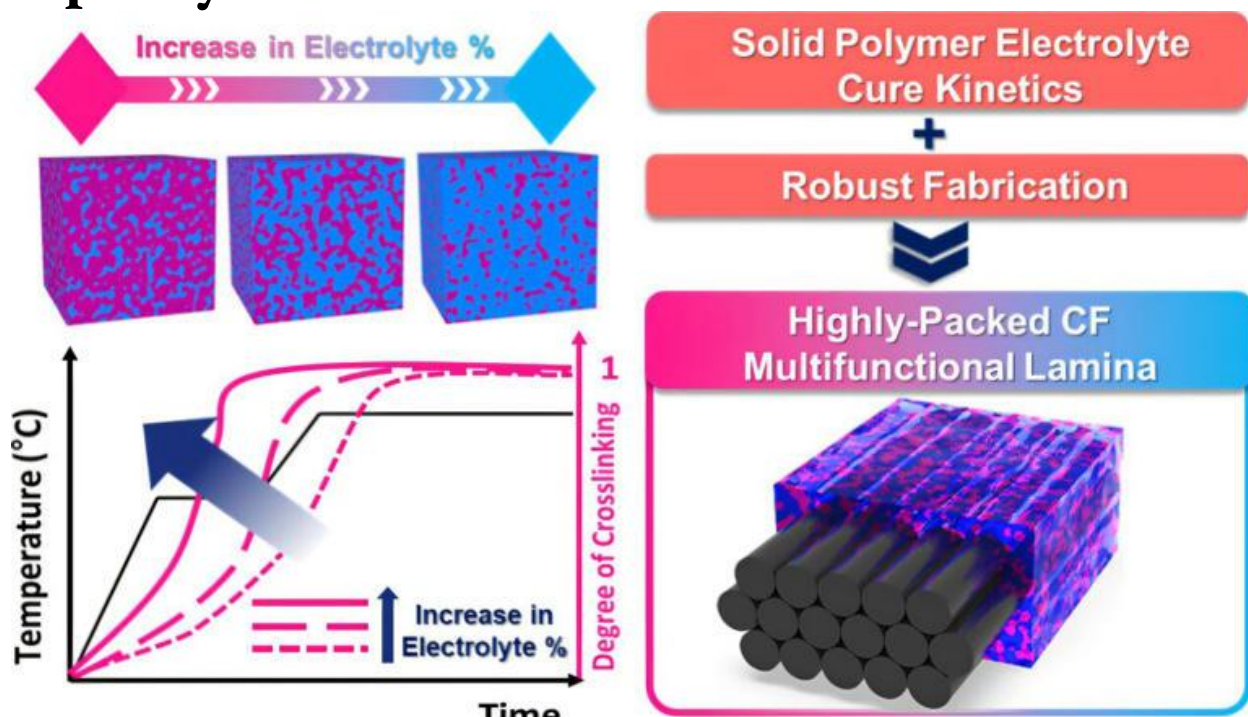
Battery safety is such a crucial metric — along with low cost, long range, and fast charge times — that researchers are trying to [improve](#) with each power pack generation. California's Liminal has developed [inspection tech](#) designed to catch battery cell flaws during production. The invention would prevent the defective

components from entering service altogether, as another example of a safety innovation.

Preventing battery overheating, thermal runaway, and fires can contribute to a positive cascade effect for consumers. Safer batteries can reduce anxiety among fire-wary vehicle buyers, nixing one of the hurdles to faster EV adoption.

technology to ensure customers can use electric vehicles with confidence and contribute to strengthening our competitiveness in the battery market," Lee said in the LG news release.

Multifunctional structural battery achieves both high energy density and load-bearing capacity



Credit: ACS Applied Materials & Interfaces (2024). DOI: 10.1021/acsami.4c08698

Structural batteries are used in industries such as eco-friendly, energy-based automobiles, mobility, and aerospace, and they must simultaneously meet the

requirements of high energy density for energy storage and high load-bearing capacity. Conventional structural battery technology has struggled to enhance both functions concurrently. However, KAIST researchers have succeeded in developing foundational technology to address this issue.

Professor Seong Su Kim's team from the Department of Mechanical Engineering has developed a thin, uniform, high-density, multifunctional structural carbon fiber composite battery capable of supporting loads, and that is free from fire risks while offering high energy density. The research is [published](#) in *ACS Applied Materials & Interfaces*.

Early structural batteries involved embedding commercial lithium-ion batteries into layered composite materials. These batteries suffered from low integration of their mechanical and electrochemical properties, leading to challenges in material processing, assembly, and design optimization, making commercialization difficult.

To overcome these challenges, Professor Kim's team explored the concept of "energy-storing composite materials," focusing on interface and curing properties, which are critical in traditional composite design. This led to the development of high-density multifunctional structural carbon fiber composite batteries that maximize multifunctionality.

The team analyzed the curing mechanisms of epoxy resin, known for its strong mechanical properties, combined with ionic liquid and carbonate electrolyte-based solid polymer electrolytes. By controlling temperature and pressure, they were able to optimize the curing process.

The newly developed structural battery was manufactured through vacuum compression molding, increasing the volume fraction of carbon fibers—serving as both electrodes and current collectors—by over 160% compared to previous carbon-fiber-based batteries.

This greatly increased the contact area between electrodes and electrolytes, resulting in a high-density structural battery with improved electrochemical performance. Furthermore, the team effectively controlled air bubbles within the structural battery during the curing process, simultaneously enhancing the battery's mechanical properties.

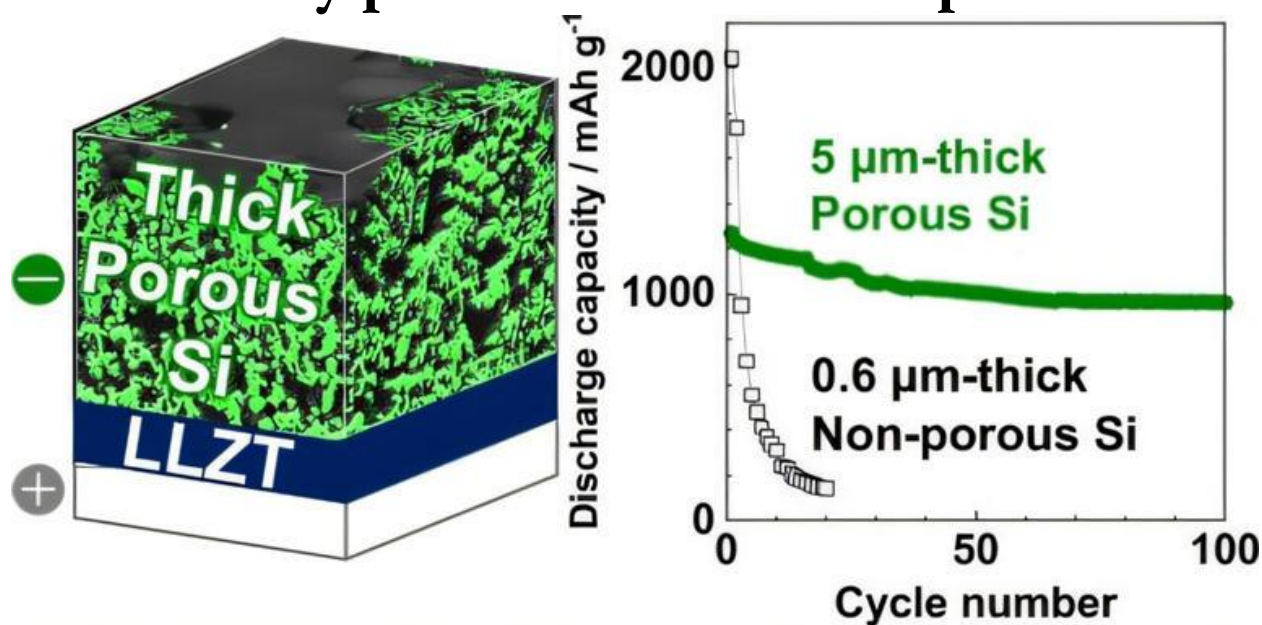
Professor Kim, the lead researcher, explained, "We proposed a framework for designing solid polymer electrolytes, a core material for high-stiffness, ultra-thin structural batteries, from both material and structural perspectives.

"These material-based structural batteries can serve as internal components in cars, drones, airplanes, and robots, significantly extending their operating time with a single charge. This represents a foundational technology for next-generation multifunctional energy storage applications."

More information: Mohamad A. Raja et al, Thin, Uniform, and Highly Packed Multifunctional Structural Carbon Fiber Composite Battery Lamina Informed by Solid Polymer Electrolyte Cure Kinetics, *ACS Applied Materials & Interfaces* (2024). DOI: [10.1021/acsami.4c08698](https://doi.org/10.1021/acsami.4c08698)

Provided by The Korea Advanced Institute of Science and Technology (KAIST)

Porous electrode design could boost all-solid-state battery performance and lifespan



Graphical abstract. Credit: ACS Applied Materials & Interfaces (2024). DOI: [10.1021/acsami.4c15894](https://doi.org/10.1021/acsami.4c15894)

Batteries have become an integral component of modern technology.

Lithium-ion batteries (LIBs) can be found virtually everywhere, from handheld electronic devices and electric vehicles to the large power banks used in renewable energy generation systems. However, current LIB designs suffer from some crippling drawbacks, including low durability and the use of toxic liquid electrolytes.

To address these limitations, scientists have been studying all-solid-state batteries for over a decade. Although silicon-based all-solid-state batteries should be theoretically more durable than conventional LIBs, an unsolved challenge still stands before this becomes a reality.

When a Si-based all-solid-state battery undergoes charge/discharge cycles, the negative Si electrode repeatedly expands and contracts. This puts a lot of mechanical stress on the interface between the electrode and the stiff solid electrolyte, causing the former to ultimately crack, detach, and suffer an irreversible dip in performance.

Against this backdrop, a research team led by Professor Takayuki Doi from Doshisha University, Japan, explored a promising solution for all-solid-state batteries.

As explained in their paper, which was made available online and [published in *ACS Applied Materials & Interfaces*](#) on October 29, 2024, the researchers investigated whether adding pores to a silicon oxide (SiO_x) electrode could prevent the cracking and peeling problems caused by the expansion and contraction seen in Si electrodes.

The study was co-authored by Dr. Kohei Marumoto from Doshisha University, Japan, and Dr. Kiyotaka Nakano from Hitachi High-Tech Corporation, Japan.

To test their hypothesis, the researchers synthesized porous SiO_x electrodes via radiofrequency sputtering and used them to fabricate various all-solid-state cells, using Li-La-Zr-Ta-O (LLZTO) as a solid electrolyte. They analyzed the obtained pore structures in detail using advanced scanning electron microscopy

techniques and investigated their correlation with the overall performance of the cells after repeated charge/discharge cycles.

Interestingly, the highly porous SiO_x electrodes offered much better cycling performance compared to non-porous SiO_x , which suffered from a massive capacity drop after cycling. Microscopy observations clearly explained what was going on at the nanometer scale.

"Non-porous SiO_x partially exfoliated from the LLZTO electrolyte by the 20th cycle, which was consistent with the drastic decline in capacity and rise in internal resistance we observed," says Dr. Doi.

"In contrast, though the initially observed pore structure of porous SiO_x collapsed through repeated expansion and contraction, the remaining pores still served as a buffer against the internal and interfacial stresses. This ultimately helped maintain the interfacial joint between the electrode and the electrolyte."

One pressing limitation of both Si and SiO_x electrodes in all-solid-state batteries is that their thickness must be kept extremely low (less than a micrometer) to prevent cracking and exfoliation. However, after adding pores to SiO_x , stable charge-discharge cycles could be obtained even in SiO_x films as thick as 5 μm .

This translates to a massive boost in terms of space efficiency, as more energy can be stored per unit volume. "The thicker SiO_x films we achieved resulted in an energy density of the negative electrode approximately 17 times higher than that of conventional non-porous silicon electrodes," highlights Dr. Doi.

Taken together, the findings of this study shed light on how porous structures can be leveraged to unlock the true potential of all-solid-state batteries. Such energy-storing devices will play a crucial role in charting our path towards sustainable societies, given their promising applications in domestic and industrial-scale energy generation.

Moreover, thanks to their enhanced safety profile and longer lives, all-solid-state batteries could make electric vehicles a much more attractive option for consumers.

"We expect the results of our research to make a multifaceted contribution towards sustainable development goals, not only in terms of climate change

countermeasures based on the reduction of carbon emissions, but also in terms of economic growth and urban development," adds Dr. Doi, while sharing his concluding thoughts.

Further studies will be needed to fully optimize the porous structure of solid SiO_x electrolytes to achieve maximum performance in all-solid-state batteries. With much luck, future developments in this exciting field will lead to a much-needed breakthrough in energy storage.

More information: Kohei Marumoto et al, Tailored Design of a Nanoporous Structure Suitable for Thick Si Electrodes on a Stiff Oxide-Based Solid Electrolyte, *ACS Applied Materials & Interfaces* (2024). DOI: [10.1021/acsami.4c15894](https://doi.org/10.1021/acsami.4c15894)

Provided by Doshisha University

Fast-charging lithium-sulfur battery revolutionizes EVs and eVTOL aircraft

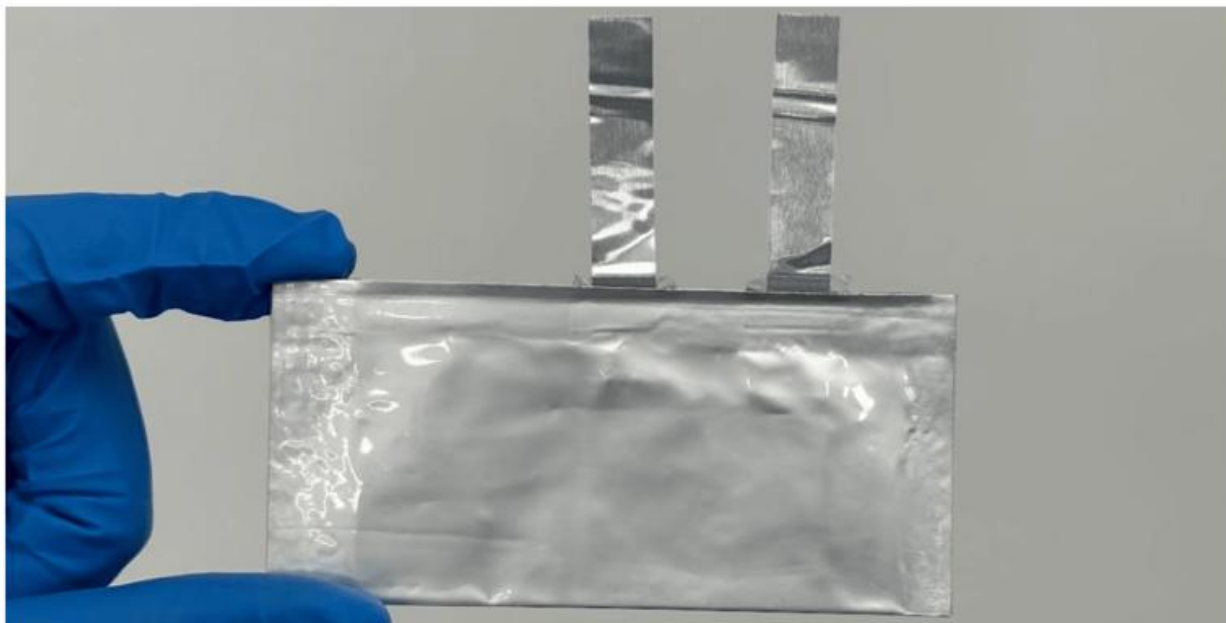
Lithium-sulfur (Li-S) batteries are emerging as a promising alternative

for [high-performance energy storage](#). Offering the potential for lighter, more energy-dense systems, these batteries are poised to revolutionize sectors like aviation, electric vehicles (EVs), and renewable energy.

Despite their potential, slow reaction kinetics during charge and discharge cycles have hindered their real-world applications—until now.

Researchers at Monash University have made a groundbreaking discovery in Li-S technology. By harnessing the unique properties of a polyvinylpyrrolidone (PVP)-iodine binder system, they significantly improved the battery's reaction kinetics, allowing for faster and more efficient charging and discharging.

This innovation, published in [Advanced Energy Materials](#), marks a transformative moment in battery technology and paves the way for commercial applications.



The Science Behind the Breakthrough

The Monash team drew inspiration from the chemistry of betadine, a common antiseptic, to address the slow charge and discharge rates of Li-S batteries. A key innovation lies in the use of polyiodide species within a polar network of PVP.

These complexes accelerate the transition between solid and liquid phases during [battery cycling](#), enhancing reaction pathways through inter-valence polyiodide reactions.

Density functional theory calculations revealed that the PVP-iodine complexes not only strengthen polysulfide binding but also introduce additional energy states. This combination accelerates the electrochemical reactions, overcoming a

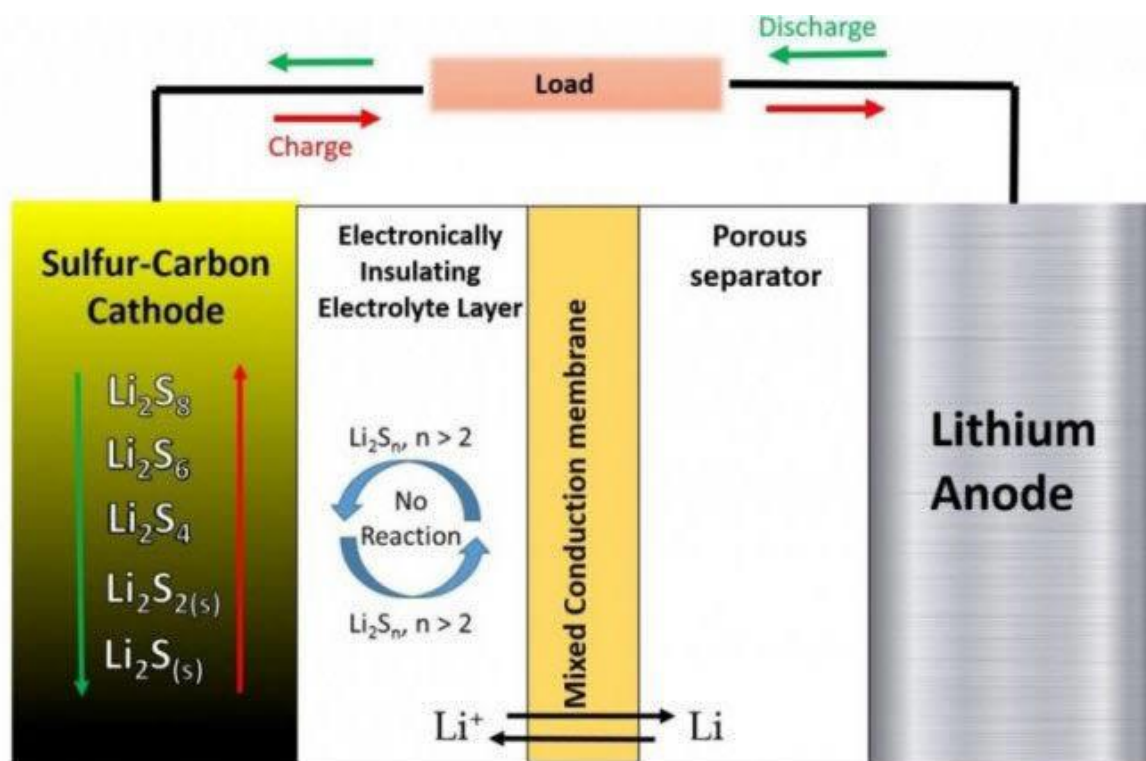
The results are impressive: the improved batteries deliver an areal capacity of approximately 7 mAh/cm² at a practical 0.5C rate, while pouch cells achieve energy densities of 215 Wh/kg at 0.1C and 156 Wh/kg at 0.3C. These metrics position the Monash-developed batteries among the highest-performing Li-S prototypes reported to date.

Advancing Real-World Applications

According to Maleesha Nishshanke, the study's lead author, the batteries not only double the energy density of conventional lithium-ion cells but are also

significantly lighter. "This advancement makes Li-S batteries a viable option for heavy-duty applications like [electric vehicles and drones](#)," she explained.

Co-lead author Dr. Petar Jovanović emphasized the transformative potential of this technology. "Li-S batteries could power long-haul EVs and commercial drones, while bringing sustainable electric aviation closer to reality," he noted. The lightweight design and high energy density are critical for industries like aviation and maritime, where weight and power reliability are paramount.



For electric vehicles, the implications are staggering. A single charge could power an EV for over 1,000 kilometers, with recharge times reduced to just a few hours. Dr. Jovanović illustrated the impact: "An EV could travel from Melbourne to Sydney on one charge, while [smartphones](#) could fully recharge in minutes."

A key challenge for Li-S batteries has been maintaining performance without rapid degradation. According to Professor Mainak Majumder, co-lead researcher and Director of the ARC Research Hub for Advanced Manufacturing with 2D Materials, the new design resolves this issue. "We've leveraged sulfur's unique chemistry to make a battery that's both safer and more efficient," he explained.

The team's novel catalyst enhances the C-rate performance, enabling batteries to handle high discharge rates during demanding activities like [take-offs in aviation](#). Early prototypes demonstrated energy densities up to 400 Wh/kg, showing promise for scaling up to larger commercial cells.

Beyond performance, Li-S batteries offer environmental advantages. Unlike lithium-ion batteries that depend on cobalt—a limited and often environmentally damaging resource—Li-S systems rely on sulfur, which is abundant and more sustainable. This makes the technology not only cost-effective but also eco-friendly.

Economic Implications and Future Directions

As global demand for high-performance batteries surges, the lithium-sulfur market is projected to reach USD 209 million by 2028. Professor Majumder believes that [Monash's pioneering work](#) positions Australia as a leader in this burgeoning industry. "This emerging sector could create jobs, drive economic growth, and establish Australia as a key player in battery innovation," he stated.

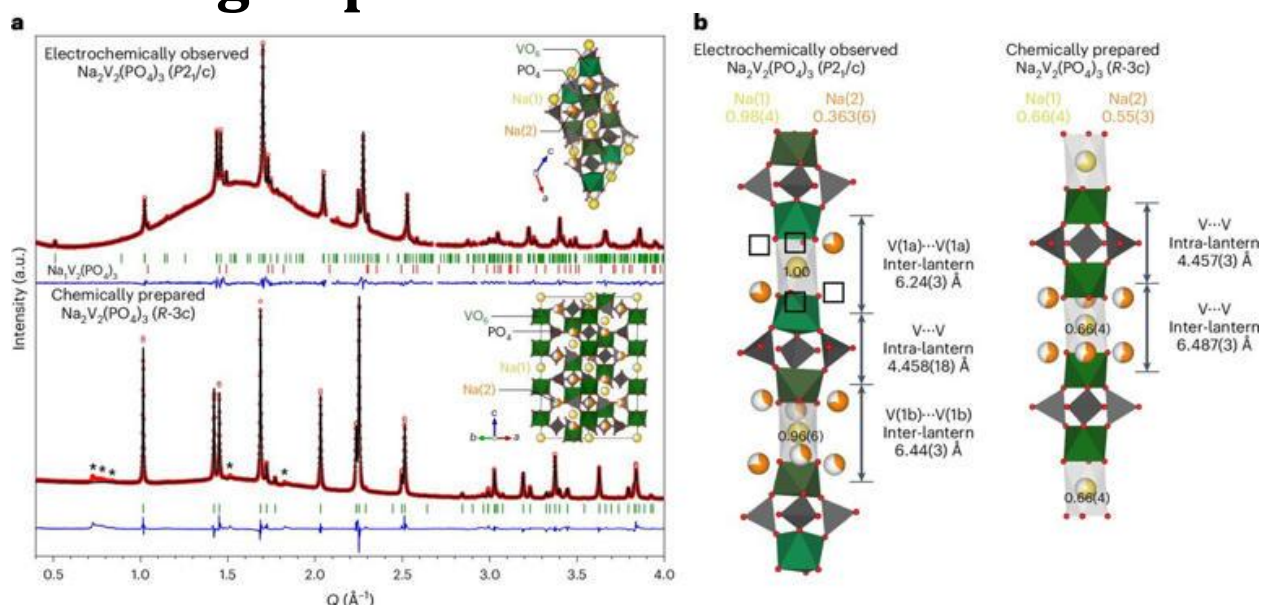
The team continues to refine the technology, focusing on additives that could further enhance charging and discharging speeds while minimizing lithium requirements. These innovations aim to address the growing need for sustainable energy solutions in sectors ranging from consumer electronics to heavy industry.

Ghove Energy, a startup supported by the research team, is actively raising pre-seed funding to commercialize this breakthrough. Investors are being invited to participate in what could become a transformative venture for renewable energy storage.

The potential applications of this technology are vast. From powering long-haul EVs to enabling [electric aircraft](#), the possibilities are redefining the boundaries of what batteries can achieve. Supported by the U.S. Air Force Office of Sponsored Research, Monash's work demonstrates international recognition of its cutting-edge expertise.

As industries demand more efficient and sustainable energy solutions, Li-S technology offers a glimpse of a greener, more electrified future. By addressing critical challenges like charging speed and energy density, these batteries could soon become the standard for high-performance, sustainable energy storage.

New material for sodium-ion batteries brings affordable, sustainable future within grasp



Structural variations in c- $\text{Na}_2\text{V}_2(\text{PO}_4)_3$ and e- $\text{Na}_2\text{V}_2(\text{PO}_4)_3$. Credit: Nature Materials (2024). DOI: 10.1038/s41563-024-02023-7

While lithium-ion batteries have been the go-to technology for everything from smartphones and laptops to electric cars, there are growing concerns about the future because lithium is relatively scarce, expensive and difficult to source, and may soon be at risk due to geopolitical considerations. Scientists around the world are working to create viable alternatives.

An international team of interdisciplinary researchers, including the Canepa Research Laboratory at the University of Houston, has developed a new type of material for sodium-ion batteries that could make them more efficient and boost their energy performance—paving the way for a more sustainable and affordable energy future.

The findings are [published](#) in the journal *Nature Materials*.

The new material, sodium vanadium phosphate with the chemical formula $\text{Na}_x\text{V}_2(\text{PO}_4)_3$, improves sodium-ion battery performance by increasing the energy density—the amount of energy stored per kilogram—by more than 15%. With a

higher energy density of 458 watt-hours per kilogram (Wh/kg) compared to the 396 Wh/kg in older sodium-ion batteries, this material brings sodium technology closer to competing with lithium-ion batteries.

"Sodium is nearly 50 times cheaper than lithium and can even be harvested from seawater, making it a much more sustainable option for large-scale energy storage," said Pieremanuele Canepa, Robert Welch assistant professor of electrical and computer engineering at UH and lead researcher of the Canepa Lab.

"Sodium-ion batteries could be cheaper and easier to produce, helping reduce reliance on lithium and making battery technology more accessible worldwide."

From theory to reality

The Canepa Lab, which uses theoretical expertise and computational methods to discover new materials and molecules to help advance clean energy technologies, collaborated with the research groups headed by French researchers Christian Masquelier and Laurence Croguennec from the Laboratoire de Réactivité et de Chimie des Solides, which is a CNRS laboratory part of the Université de Picardie Jules Verne, in Amiens France, and the Institut de Chimie de la Matière Condensée de Bordeaux, Université de Bordeaux, Bordeaux, France for the experimental work on the project. This allowed theoretical modeling to go through experimental validation.

The researchers created a battery prototype using the new material, $\text{Na}_x\text{V}_2(\text{PO}_4)_3$, demonstrating significant energy storage improvements. $\text{Na}_x\text{V}_2(\text{PO}_4)_3$, part of a group called "Na superionic conductors" or NaSICONs, is designed to let sodium ions move smoothly in and out of the battery during charging and discharging.

Unlike existing materials, it has a unique way of handling sodium, allowing it to work as a single-phase system. This means it remains stable as it releases or takes in sodium ions. This allows the NaSICON to remain stable during charging and discharging while delivering a continuous voltage of 3.7 volts versus sodium metal, higher than the 3.37 volts in existing materials.

While this difference may seem small, it significantly increases the battery's energy density or how much energy it can store for its weight. The key to its

efficiency is vanadium, which can exist in multiple stable states, allowing it to hold and release more energy.

"The continuous voltage change is a key feature," said Canepa. "It means the battery can perform more efficiently without compromising the electrode stability. That's a game-changer for sodium-ion technology."

Possibilities for a sustainable future

The implications of this work extend beyond sodium-ion batteries. The synthesis method used to create $\text{Na}_x\text{V}_2(\text{PO}_4)_3$ could be applied to other materials with similar chemistries, opening new possibilities for advanced energy storage technologies. That could in turn, impact everything from more affordable, sustainable batteries to power our devices to help us transition to a cleaner energy economy.

"Our goal is to find clean, sustainable solutions for energy storage," Canepa said. "This material shows that sodium-ion batteries can meet the high-energy demands of modern technology while being cost-effective and environmentally friendly."

Ziliang Wang, Canepa's former student and now a postdoctoral fellow at Northwestern University, and Sunkyu Park, a former student of the French researchers and now a staff engineer at Samsung SDI in South Korea, performed much of the work on this project.

More information: Sunkyu Park et al, Obtaining $\text{V}_2(\text{PO}_4)_3$ by sodium extraction from single-phase $\text{Na}_x\text{V}_2(\text{PO}_4)_3$ ($1 < x < 3$) positive electrode materials, *Nature Materials* (2024). DOI: [10.1038/s41563-024-02023-7](https://doi.org/10.1038/s41563-024-02023-7)

Provided by University of Houston

Will This Device Solve EV Battery Heat Issues?

- **Hyundai Mobis has developed a new battery-cell cooling device dubbed Pulsating Heat Pipe (PHP), designed to transfer heat from between cells to the exterior more efficiently.**
- **The device, composed of aluminum alloy and refrigerant, is designed to be positioned between the battery cells themselves, working to dissipate heat during DC fast-charging.**
- **The company says that PHP offers 10 times the heat transfer performance of common aluminum, lowering the amount of charging time required by permitting faster charging cycles.**

In the race to field EV batteries that promise the longest driving distances and the fastest recharge capabilities, one particular quality often gets overlooked in the marketing frenzy, and that's the ability of the current crop of lithium-ion batteries to cool themselves.

In fact, it seems the only time we hear about the thermal safety of EV batteries is when there isn't enough of it and an EV catches fire, leading to recommendations that involve leaving the car outside at night.

But until [solid-state designs](#) begin arriving in production cars—an EV industry wish list item perpetually a couple of years away—the thermal safety of lithium-ion compositions will continue to be an engineering issue to be addressed with extra care.

Hyundai Mobis, the automaker's parts division, now reveals that it has developed a new battery-cell cooling device dubbed Pulsating Heat Pipe (PHP).

Composed of aluminum alloy and refrigerant, this device is designed to be integrated between the battery cells themselves, with the aim of lowering the internal battery temperature during fast-charging cycles.

The pipes themselves are essentially metal-tube-shaped thermal conductors, and they operate by diffusing the heat through vibration while circulating the

refrigerant internally, thereby moving the heat from the battery cells to the exterior.



PHP promises greater cooling efficiency during charging, Hyundai Mobis says.© Hyundai

Hyundai Mobis adds that the technology offers 10 times the heat transfer performance of common aluminum.

Of course, as with other new battery technologies, the leap from the lab to the assembly line can be a long and expensive one, as we've seen by now. But the company is optimistic about putting PHPs into production with minimal effort at the manufacturing level.

"Hyundai Mobis applied a press process enabling large-scale continuous production in the manufacturing stage, simplifying the PHP manufacturing process and reducing production costs," Hyundai Mobis says.

The company notes that a lower temperature will permit faster charging speeds and reduce time that owners will need to spend at the charging station.

The issue of cooling EV batteries concerns one other often unmentioned parameter: battery weight as a result of the cooling systems needed. This is an issue that PHP technology could address, making electrically driven cooling fans unnecessary, or at the very least not as bulky.

If PHP faces a competitor in the battery tech sphere at all, it is likely to be solid-state designs that promise much greater thermal safety, eliminating the need for extensive cooling hardware. But before we actually see solid-state designs en masse, these thermal benefits, along with others, will likely remain confined to the lab.

"Hyundai Mobis aims to secure world-class battery cooling technology and commercialize it to enhance its competitiveness in the future mobility market," the company added.

Is the possibility of **thermal-runaway events that cause battery fires** still an issue for EV shoppers, or has that problem largely faded from the consumer mind? Let us know what you think in the comments below.

Scientists develop high-tech battery with incredible capabilities — here's how it could slash electric car prices



Scientists develop high-tech battery with incredible capabilities — here's how it could slash electric car prices

Battery experts are using an interesting tactic in the effort to develop a better power pack. Instead of shunning graphite, as others have, they are reinventing how it's configured, [according](#) to a news release from the University of Waterloo lab in Canada.

And the result has a clear benefit for [electric vehicle](#) drivers: a zero-to-80% charge in 15 minutes, per the experts.

As part of the work, scientists fused graphite material together in a novel approach to form an anode, which they [reported](#) improves conductivity. Graphite is a crucial, effective battery substance subject to sometimes troublesome [foreign supply chains](#).

China harvests about 70% of the worldwide supply, with control of nearly all of the refining process, S&P Global [reported](#). That's partly why battery experts at Panasonic and elsewhere are experimenting with more common [silicon](#) as a replacement, with potential to also [boost performance](#).

By rethinking how to form the graphite anode, the Waterloo team [says it has](#) invented one that's safe, doesn't degrade quickly, and can handle a fast charge. What's more, it can easily be included in existing battery production lines. When batteries [operate](#), ions travel between the anode and cathode through the electrolyte.

"We're not reinventing the wheel in terms of materials in lithium-ion batteries. We're just finding a better way to arrange the particles and providing new functions to the binders that hold them together such as state-of-the-art electron, ion, and heat transfer properties," Professor Michael Pope [said](#) in the lab summary.

The Waterloo team touted the 15-minute charge time as a clear advantage to common packs on the market that can take an hour or longer to repower. Charge speeds often depend on the [mechanism](#), but standard home outlets typically require overnight charging. [Tesla's](#) network of more than 60,000 Superchargers, located around the world, can now provide [200 miles](#) of range in a quarter of an hour, per the company.

The Waterloo pack can also ably operate for up to 800 cycles. The collection of perks are important to ease motorist [range](#) and cost anxiety, the researchers stated.

"We need to make EVs more affordable and accessible, not just for the wealthy," Professor Yverick Rangom said. "If we can make batteries smaller, charge faster, and last longer, we reduce the overall cost of the vehicle. That makes EVs a viable option for more people."

Most of the concerns are already receding. The Ford Mustang Mach E recently set a range record at [569.64 miles](#) on a single charge. U.S. News & World Report [listed](#) some of the cheapest models available, including the [Nissan Leaf](#), starting at around \$30,000. Ford is even [paying](#) for charge [tech](#) to be installed at the buyer's home.

Valuable tax breaks of up to [\\$7,500](#) remain available for certain models, as well. That's in addition to recurring gas and maintenance savings worth up to [\\$1,500](#) per year.

Perhaps the biggest win to thriving EV adoption is reducing heat-trapping air pollution, [linked](#) by NASA to a greater risk for a troubling list of [severe weather](#) events. Each EV that replaces a gas-burner [prevents](#) thousands of pounds of planet-warming fumes each year, per government data.

Graphite has been a key part of the batteries powering most EVs so far. And for their part, Waterloo's experts plan to keep the valuable material relevant.

"We're focused on ensuring this solution is not only effective, but scalable," Rangom [said](#) in the summary.

New superionic battery tech could boost EV range to 600+ miles on single charge

A key challenge in developing all-solid-state lithium metal batteries (LMBs) has been the need for safe, reliable, high-performance solid-state electrolytes (SSEs).

Researchers have developed an advanced SSE with high ionic conductivity, enabling ultra-stable lithium metal batteries with exceptional cycling stability, high capacities, and fast charge-discharge rates.

The SSE paves the way for developing batteries with energy densities of up to 500 Wh/kg, thereby extending the driving range to over 600 miles per charge (965 kilograms).

The material, developed by Western University in Canada, the University of Maryland in the United States, and other institutions, supports stable performance in all-solid-state LMBs.

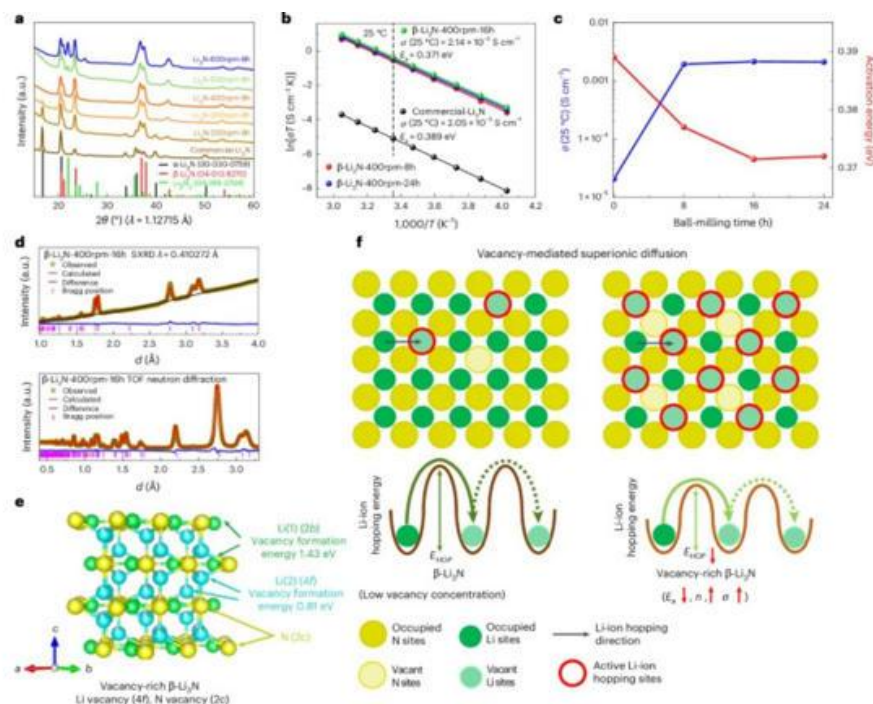
According to the team, the development could help make LMBs more practical for commercial use.

Vacancy-driven battery innovation

All-solid-state LMBs promise safer, high-energy alternatives to traditional lithium-ion batteries by replacing flammable liquid electrolytes. However, practical use faces challenges with lithium metal anodes and SSEs like oxides, sulfides, and halides.

Lithium dendrites readily cross oxide grain boundaries at high currents, posing a failure risk, whereas sulfide- and halide-based SSEs produce detrimental side reactions at the lithium interface.

Although they increase complexity and expense, protective layers called interlayers can stabilize the lithium metal anode. Current approaches, necessitating SSEs with improved ionic conductivity and stability do not meet the demands of large capacity and fast charging.



XRD patterns and conductivity data show ball-milled β-Li₃N with high lithium-ion conductivity and a vacancy-mediated diffusion mechanism.

Studies reveal that nitride-based SSEs, such as Li₃N, have exceptional stability against lithium. Dendritic hazards are decreased by the β-Li₃N phase's enhanced ionic conductivity and decreased electronic conductivity.

According to the team, to enhance performance, increasing lithium vacancies in β-Li₃N can boost ionic conductivity and stability during lithium stripping/plating. This approach addresses key issues, making all-solid-state LMBs more viable for high-performance applications.

Advanced energy storage

The new research led to the development of a highly **lithium**-compatible, air-stable β-Li₃N solid-state electrolyte (SSE) with a vacancy-rich structure, achieving record-breaking performance.

"Our design of the vacancy-rich β-Li₃N was guided by an understanding of lithium-ion conduction mechanisms. Defects in the crystal structure, such as vacancies, can reduce the energy barriers for lithium-ion migration and increase the population of mobile lithium ions," Weihai Li, Junior Research Group Leader

at RWTH Aachen University and the first author of the research paper, states [Phys.org](#).

The researchers created the vacancy-rich β -Li₃N SSE through a high-energy ball-milling process. The method introduced a precise number of vacancies into the material's structure, significantly improving its properties.

The material exhibits exceptional ionic conductivity of $2.14 \times 10^{-3} \text{ S cm}^{-1}$ at room temperature, outperforming most nitride-based SSEs. Advanced diffraction techniques, simulations, and calculations reveal a vacancy-mediated superionic diffusion mechanism that drives the rapid lithium-ion movement.

The vacancy-rich β -Li₃N resists lithium dendrite growth, supports critical current densities up to 45 mA cm^{-2} , and maintains stable cycling for over 4,000 hours at 7.5 mA cm^{-2} . Its stability with lithium metal is explained by density functional theory and X-ray microscopy studies. Additionally, it demonstrates high air stability in dry environments.

Using this SSE, researchers [designed](#) all-solid-state lithium [metal](#) batteries with lithium metal anodes and LiCoO₂ (LCO) or Ni-rich NCM83 cathodes. These batteries showed long cycle life, retaining 82.05 percent capacity over 5,000 cycles for LCO and 92.5 percent over 3,500 cycles for NCM83 at 1.0 C.

They also offer fast charging at up to 5.0 C and achieve high areal capacities in both pellet and pouch cells, making them promising for next-generation energy storage.

The details of the team's [research](#) were published in the journal *Nature Nanotechnology*

Lithium-Air Battery: How It Works, Breakthrough Design, and Future Potential

November 8, 2024 by [Ellis Gibson \(B.Sc. in Mechanical Engineering\)](#)

A lithium-air battery works by reacting lithium ions with oxygen in the air. During discharge, this creates lithium oxide at the positive electrode. Studies, like those by Chiang et al., investigate new flow cell designs to enhance efficiency and performance in energy storage systems.

The breakthrough design of lithium-air batteries features a lightweight and abundant material—air—as a reactant. This design reduces weight compared to traditional lithium-ion batteries, making lithium-air batteries potentially ideal for electric vehicles and portable electronics. The higher energy density of lithium-air batteries offers the promise of extended range for electric cars, addressing a major limitation of existing technologies.

Despite their potential, lithium-air batteries face challenges. They struggle with issues such as short cycle life and inefficiencies in the oxygen reduction reaction. Ongoing research aims to optimize materials and improve performance.

As researchers continue to explore lithium-air battery technology, the future potential remains exciting. Sustainable and efficient energy storage could transform various industries, leading us into a new era of clean energy solutions. The next section will delve into the latest advancements in material science that could shape the future of lithium-air batteries.

What Is a Lithium-Air Battery and Why Is It Significant?

A lithium-air battery is an innovative energy storage system that utilizes lithium as the anode and oxygen from the air as the cathode. This type of

battery has the potential to offer high energy density, meaning it can store more energy in a smaller space compared to traditional batteries.

The U.S. Department of Energy describes lithium-air batteries as having the capability to reach energy densities of over 300 Wh/kg, which surpasses current lithium-ion technologies. This feature makes them promising candidates for electric vehicles and large-scale energy storage solutions.

Lithium-air batteries operate through a chemical reaction between lithium ions and oxygen, producing electricity. The process involves charging and discharging cycles, where lithium forms lithium peroxide during discharge and returns to lithium during charge. Their significance lies in the potential to reduce weight and size in applications where space and weight are crucial.

According to a study published in *Nature Energy*, lithium-air batteries could revolutionize the energy landscape if technical challenges related to efficiency and cycle stability are addressed. The same study indicates that improving these batteries can lead to enhancements in electric vehicle ranges and energy storage systems.

Lithium-air batteries could dramatically influence the energy sector by providing alternatives that lower dependency on fossil fuels. Their development may contribute to cleaner energy solutions, reducing greenhouse gas emissions and promoting sustainable practices.

Societal impacts include higher energy efficiency and lower operational costs for consumers and industries. Environmentally, a successful transition to lithium-air technology could mean reduced resource extraction and less pollution.

High-profile projects illustrating these benefits include partnerships between automotive companies and battery researchers aiming to commercialize lithium-air technology. For example, Tesla's exploration into advanced battery technologies highlights the industry's commitment to innovation.

Experts from organizations like the International Energy Agency recommend research funding and public-private partnerships to accelerate the development of lithium-air batteries. Such measures would enhance technical viability and promote widespread adoption.

Strategies for improving lithium-air technology include advancing cathode design and improving cycle management. Research into new materials and architectures can enhance performance and stability in practical applications.

How Does a Lithium-Air Battery Work?

A lithium-air battery operates by converting chemical energy into electrical energy through a series of electrochemical reactions. The main components of this battery include lithium, a porous carbon electrode, and oxygen from the air.

First, during discharging, lithium ions move from the anode, which is made of lithium, to the cathode, which contains the porous carbon structure. At the cathode, oxygen from the air combines with lithium ions and electrons. This reaction produces lithium oxide, which serves as the end product of the discharge process.

The next step occurs during charging. In this phase, external energy applies to the battery. This energy drives the reverse reaction, where lithium oxide decomposes back into lithium ions and oxygen. The lithium ions return to the anode, ready for another discharge cycle.

This electrochemical process enables lithium-air batteries to achieve high energy density. The reaction utilizes oxygen from the environment, making it lightweight and potentially more efficient than traditional batteries.

In summary, a lithium-air battery works by facilitating the movement of lithium ions and the reaction with oxygen to produce electricity. This design showcases the potential for improved battery performance and energy storage solutions.

What Are the Key Components of a Lithium-Air Battery?

The key components of a lithium-air battery include a lithium anode, a cathode typically made from carbon, an electrolyte solution, and a porous separator.

1. Lithium Anode
2. Carbon-based Cathode
3. Electrolyte Solution
4. Porous Separator

The presence of these components plays a critical role in the functionality and performance of lithium-air batteries. Let's explore each component in detail.

1. **Lithium Anode:**

The lithium anode is a crucial part of lithium-air batteries. It serves as the negative electrode where lithium ions are stored and released during the battery's charging and discharging cycles. Lithium is lightweight and has a high energy density, which contributes to the overall efficiency of the battery.

2. **Carbon-based Cathode:**

The carbon-based cathode is where the oxygen reduction reaction occurs in lithium-air batteries. Typically, this cathode is made from porous carbon structures that enable oxygen from the air to enter and interact with lithium ions. These materials are chosen for their electrical conductivity and structural integrity. Studies have shown that optimized carbon cathodes can enhance battery performance significantly.

3. **Electrolyte Solution:**

The electrolyte solution in a lithium-air battery facilitates ionic movement between the anode and cathode. It is essential for conducting lithium ions during the discharge and recharge

cycles. Research indicates that the choice of electrolyte impacts the overall efficiency and longevity of the battery. Liquid electrolytes, gel polymers, and solid-state forms can all be employed depending on the desired application and performance metrics.

4. **Porous Separator:**

The porous separator acts as a barrier between the anode and cathode, preventing short circuits while allowing the movement of lithium ions. It helps maintain the integrity of the battery and contributes to its safety. The material and pore structure of the separator can influence the battery's performance characteristics, such as energy density and rate capability.

Understanding these key components provides insight into the innovative design and potential applications of lithium-air batteries in energy storage solutions.

How Does the Electrochemical Reaction Occur in a Lithium-Air Battery?

The electrochemical reaction in a lithium-air battery occurs when lithium ions interact with oxygen from the air. This process takes place in two primary reactions: the oxidation of lithium at the anode and the reduction of oxygen at the cathode.

First, lithium metal at the anode loses electrons, initiating the oxidation reaction. This generates lithium ions. The lithium ions then travel through an electrolyte, which is a substance that conducts electricity, to reach the cathode.

At the cathode, the oxygen from the air reacts with the incoming lithium ions and the electrons that arrive via an external circuit. This reaction produces lithium peroxide or lithium oxide, depending on various conditions. The formation of this product releases energy, powering the connected device.

Finally, when the lithium-air battery discharges, it effectively converts chemical energy into electrical energy. This entire cycle is reversible, allowing the battery to be recharged by applying an external current, which drives the reverse reactions. Overall, the electrochemical reaction in a lithium-air battery is an efficient way to harness energy by utilizing the abundant oxygen in the atmosphere.

What Are the Advantages of Lithium-Air Batteries Compared to Other Technologies?

Lithium-air batteries offer significant advantages over other battery technologies, particularly in energy density and weight.

1. High energy density
2. Lightweight design
3. Potential for lower cost
4. Environmentally friendly materials
5. Longer lifecycle potential

These advantages highlight the promising potential of lithium-air batteries, although there are challenges that must be addressed before they can become widely adopted.

1. **High Energy Density:**
High energy density in lithium-air batteries refers to their ability to store a large amount of energy relative to their weight. This characteristic makes them more efficient than traditional lithium-ion batteries. A study by J. D. Whittingham in 2009 noted that lithium-air batteries could potentially achieve energy densities up to 10 times greater than lithium-ion batteries, making them ideal for applications in electric vehicles (EVs) and portable electronics. For instance, this could enable electric cars to travel longer distances on a single charge.

2. Lightweight Design:

The lightweight design of lithium-air batteries stems from their reliance on air for one of the reactants instead of heavy metal oxides. This significant reduction in weight directly enhances the battery's performance in applications where weight is critical, such as in aviation and electric vehicles. A report by the U.S. Department of Energy in 2017 highlighted that reducing weight could improve the efficiency and range of electric vehicles.

3. Potential for Lower Cost:

Lithium-air batteries have the potential for lower costs due to the abundance of materials used, primarily lithium and air. Unlike other technologies that rely on expensive materials such as cobalt, the cost of lithium-air batteries could be significantly lower. According to a market analysis performed by the International Energy Agency in 2020, cost savings from these materials could lead to decreased consumer prices for electric vehicles.

4. Environmentally Friendly Materials:

Lithium-air batteries utilize materials that have a lower environmental impact compared to traditional batteries. They primarily use lithium, which, when mined responsibly, can minimize ecological damage. Furthermore, since air is an abundant resource, the overall environmental footprint is less significant. The Environmental Protection Agency (EPA) emphasizes the importance of transitioning to greener technologies, highlighting the potential of lithium-air batteries to reduce waste.

5. Longer Lifecycle Potential:

Longer lifecycle potential in lithium-air batteries refers to the expectation that these batteries could be charged and discharged more times than traditional batteries without significant capacity loss. Research led by A. Manthiram in 2014 suggests that improvements in lithium-air battery technology

could enable lifecycles comparable to or exceeding those of present technologies. This characteristic can translate into reduced costs and enhanced sustainability over time.

Overall, lithium-air batteries present clear advantages; however, ongoing research and development are essential to overcoming the current technical challenges and realizing their full potential.

Why Are Lithium-Air Batteries Considered More Energy-Dense?

Lithium-air batteries are considered more energy-dense because they have the potential to store significantly more energy per unit weight compared to traditional lithium-ion batteries. This characteristic is primarily due to the lightweight nature of oxygen, which is used in the chemical reactions within these batteries.

The U.S. Department of Energy defines energy density as the amount of energy stored in a given system or region of space per unit volume or mass. For lithium-air batteries, this density can surpass that of lithium-ion batteries, with theoretical values reaching up to 3,500 Wh/kg, significantly higher than the 150-250 Wh/kg typical for lithium-ion technology.

The increased energy density of lithium-air batteries arises from several key factors:

1. **Use of Oxygen:** These batteries use oxygen from the air as a reactant. This reduces the need for carrying additional heavy materials, allowing for greater energy storage capacity.
2. **Chemical Reactions:** Lithium-air batteries employ lithium ions that react with oxygen to form lithium peroxide and lithium oxide. These reactions are capable of releasing a large amount of energy.

3. **Improved Materials:** Research is ongoing to improve the materials used in lithium-air systems, aiming to enhance efficiency and longevity.

Key terms include:

- **Energy Density:** The amount of energy stored relative to weight or volume.
- **Reactant:** A substance that undergoes a change during a chemical reaction.

The mechanism of a lithium-air battery involves several processes. During discharge, lithium ions move from the anode to the cathode, where they react with oxygen to form lithium oxide or lithium peroxide. During charging, this reaction reverses, allowing the battery to restore energy.

Specific conditions that contribute to the effectiveness of lithium-air batteries include:

- **Ambient Conditions:** The availability of ambient oxygen is crucial, making these batteries practical only in certain environments.
- **Electrolyte Composition:** The choice of electrolyte can significantly influence performance. The right electrolyte can enhance ionic conductivity and improve overall efficiency.
- **Temperature Control:** The battery's performance can vary with temperature, thus optimal thermal management is necessary for best results.

For instance, in electric vehicles powered by lithium-air batteries, the combination of lightweight design and high energy capacity could extend driving range significantly between charges.

What Are the Current Challenges Facing Lithium-Air Battery Technology?

Lithium-air battery technology currently faces several significant challenges that hinder its development and commercial viability.

1. Limited cycle life
2. Poor energy efficiency
3. Electrolyte stability issues
4. Electrode material degradation
5. Practical manufacturing challenges
6. Environmental concerns

These challenges highlight the complexity of advancing lithium-air battery technology and signal the need for focused research and innovation.

1. **Limited Cycle Life:**

Limited cycle life in lithium-air batteries refers to the number of charging and discharging cycles the battery can undergo before its performance significantly degrades. Research indicates that many lithium-air batteries only operate effectively for a few hundred cycles, compared to thousands of cycles for traditional lithium-ion batteries. A study by Wu et al. (2021) emphasized that current lithium-air designs experience rapid degradation mainly due to electrolyte decomposition and electrode alteration.

2. **Poor Energy Efficiency:**

Poor energy efficiency denotes the batteries' ability to convert stored energy back into useable electrical energy. Lithium-air batteries often show energy efficiency rates below 50%, which is considerably lower than that of lithium-ion counterparts. According to a review by Liu et al. (2022), this inefficiency arises from high overpotentials during both charge and discharge cycles, limiting their practical application for energy storage.

3. **Electrolyte Stability Issues:**

Electrolyte stability issues in lithium-air batteries are concerns regarding the electrolyte's ability to maintain performance under various conditions. Many conventional electrolytes decompose or react with lithium and oxygen, leading to decreased battery

performance. Research by Zhang et al. (2022) highlights that finding stable electrolytes that can withstand the oxidative environment is essential for improving battery longevity and performance.

4. Electrode Material Degradation:

Electrode material degradation refers to the deterioration of the materials used in the battery electrodes over time. In lithium-air batteries, the formation of lithium peroxide during discharge can result in the structural breakdown of electrodes. A report by Chen et al. (2023) noted that this degradation limits the batteries' capacity and efficiency, posing a significant challenge for future developments.

5. Practical Manufacturing Challenges:

Practical manufacturing challenges involve the difficulty in producing lithium-air batteries at scale. The complex structures and precise material compositions required for the effective operation of these batteries present significant hurdles to mass production. The work of Patel and Singh (2022) highlights that standardization and cost-effective methods are crucial to making lithium-air batteries commercially viable.

6. Environmental Concerns:

Environmental concerns surrounding lithium-air batteries include the sourcing of raw materials and the potential environmental impact from battery disposal. While lithium is abundant, certain elements used in some electrode designs may involve environmentally damaging extraction processes. As explored by Green et al. (2023), developing sustainable sourcing practices and efficient recycling methods will be necessary to mitigate environmental impacts associated with lithium-air battery technology.

How Do Cathode and Electrolyte Challenges Affect Performance?

Cathode and electrolyte challenges significantly impact the performance of electrochemical cells by affecting efficiency, durability, and overall energy output.

The performance of electrochemical cells can be influenced by multiple factors concerning cathodes and electrolytes. The key challenges include:

1. **Material Limitations:** The materials used for cathodes, such as lithium cobalt oxide or lithium iron phosphate, often face limitations in capacity and efficiency. Research by Naga et al. (2020) indicates that certain materials degrade over time, reducing the battery's lifespan and performance output.
2. **Conductivity Issues:** The electrolyte must effectively conduct ions between the anode and cathode. If the electrolyte has low ionic conductivity, the battery operates inefficiently. For example, Zhang et al. (2021) report that solid electrolytes can have lower conductivity than liquid counterparts, limiting performance in certain designs.
3. **Interface Stability:** The interface between the cathode and electrolyte can develop resistance over time. This resistance affects charge transfer and overall efficiency. A study by Liu et al. (2019) shows that unstable interfaces lead to increased energy losses and reduced cycle life.
4. **Temperature Sensitivity:** Electrolytes can be sensitive to temperature changes, which affects their performance. At low temperatures, ionic mobility decreases, leading to performance drop. Research by Park et al. (2022) illustrates that performance can decline significantly in cold conditions.

5. **Degradation Mechanisms:** Various degradation mechanisms, such as electrolyte decomposition or cathode material breakdown, also affect performance. A study by Chen et al. (2020) indicates that repeated charge-discharge cycles can lead to structural changes in cathode materials, further impairing battery function.

In conclusion, addressing these challenges is crucial for improving the overall efficiency and lifespan of electrochemical cells.

What Breakthrough Designs Have Emerged in Lithium-Air Battery Research?

Lithium-air battery research has produced several breakthrough designs focusing on improved efficiency, longevity, and environmental impact.

1. High-energy density designs
2. Enhanced electrocatalysts
3. Solid-state lithium-air batteries
4. Light-weight materials integration
5. Recycling and sustainability advancements

These advancements collectively offer exciting potential, yet each development has its own set of challenges and perspectives, creating a dynamic landscape of opinions in the field.

1. **High-Energy Density Designs:**
High-energy density designs in lithium-air batteries aim to maximize the energy stored per unit of weight. Researchers have demonstrated through various studies that these batteries can potentially achieve energy densities surpassing conventional lithium-ion batteries. For instance, a 2021 study by Lee et al. noted that certain lithium-air cells can theoretically reach up to

10,000 Wh/kg under optimal conditions, vastly improving upon current energy solutions.

2. Enhanced Electrocatalysts:

Enhanced electrocatalysts are essential for increasing the efficiency of lithium-air batteries' electrochemical processes. Recent research, such as the findings by Zhang et al. in 2022, highlights the use of novel materials like transition metal oxides and carbon composites. These materials significantly reduce overpotentials, leading to faster charging times and improved overall efficiency of the discharge and recharge cycles.

3. Solid-State Lithium-Air Batteries:

Solid-state lithium-air batteries represent a major innovation. They replace the liquid electrolyte with a solid electrolyte, enhancing safety and stability. Studies by Wang et al. in 2023 revealed that solid-state designs mitigate risks of leakage and thermal runaway. Furthermore, these batteries can achieve higher energy efficiencies and longer life cycles, addressing major drawbacks of traditional liquid systems.

4. Light-Weight Materials Integration:

The integration of lightweight materials into lithium-air batteries aims to improve performance in applications such as electric vehicles and portable electronics. Researchers are exploring advanced composites and nanomaterials. A study by Chen et al. in 2022 illustrated that using graphene-based materials can reduce the overall weight while maintaining structural integrity and enhancing cycling stability.

5. Recycling and Sustainability Advancements:

Recycling and sustainability advancements focus on reducing the environmental impact of lithium-air batteries. Efforts are being made to develop closed-loop systems that can effectively reclaim lithium and other materials post-use. Research published by Patel et al. in 2021 discusses methods for improving the recovery

rates of lithium from used batteries, which is crucial for creating an environmentally friendly battery lifecycle.

These breakthrough designs in lithium-air battery research reflect a complex interplay of technical innovation and practical challenges, each with unique implications for the future of energy storage.

How Can Innovations Improve Efficiency and Stability?

Innovations can improve efficiency and stability by streamlining processes, enhancing productivity, and reducing waste. These advancements often lead to cost savings and better resource management.

1. Streamlining processes: Innovations often introduce new technologies or methods that simplify operations. For instance, automation in manufacturing reduces manual intervention and shortens production time. A study by McKinsey & Company (2020) suggests that automation can lead to efficiency improvements of up to 30%.
2. Enhancing productivity: New tools and technologies enable workers to perform tasks more effectively. Cloud computing allows employees to collaborate in real-time, regardless of location. According to a report from Gartner (2021), organizations that use cloud-based solutions experience a 20% increase in productivity.
3. Reducing waste: Innovations often focus on minimizing resources while maximizing output. Lean manufacturing techniques help identify and eliminate wasteful practices. A study by the Lean Enterprise Institute (2019) found that companies applying lean principles reduced operational waste by 40%, significantly improving their overall efficiency.

4. **Cost savings:** Implementing innovative solutions can lead to substantial cost reductions. Energy-efficient technologies decrease utility expenses, while resource-saving techniques lower material costs. The U.S. Department of Energy (2022) reports that energy-efficient upgrades can save businesses an average of 30% on energy bills.
5. **Better resource management:** Advances in data analytics allow organizations to monitor resources in real-time. This capability improves decision-making, reduces overstock and shortages, and enhances overall stability. According to a report by Deloitte (2020), companies leveraging data analytics for resource management see a 15% improvement in inventory turnover rates.

In summary, the implementation of innovations results in systematic improvements that drive efficiency and stability across various sectors, leading to enhanced performance and sustainability.

What Is the Future Potential of Lithium-Air Batteries?

Lithium-air batteries are energy storage devices that use lithium as an anode and oxygen from the air as a cathode material. These batteries have the potential to deliver higher energy density than traditional lithium-ion batteries, offering a promising solution for electric vehicles and renewable energy storage.

According to the U.S. Department of Energy, lithium-air batteries could achieve theoretical energy densities up to five times greater than current lithium-ion counterparts. This makes them an attractive option for various applications requiring lightweight and efficient storage solutions.

Lithium-air batteries operate by undergoing a chemical reaction that combines lithium with oxygen, generating electricity. They differ from

lithium-ion batteries, which store energy internally. The efficiency and power of lithium-air batteries depend on various factors, including the design of the cathode, management of air flow, and electrolyte composition.

The National Renewable Energy Laboratory describes lithium-air batteries as potentially revolutionary, stating that their high energy density could significantly enhance the range of electric vehicles. However, challenges remain, such as poor cycle life and electrolyte evaporation.

Research indicates that lithium-air batteries can theoretically achieve energy densities of about 3,500 Wh/kg, compared to approximately 150 Wh/kg for lithium-ion batteries, presenting a significant opportunity for future advancements in energy technology.

The broader impact of lithium-air batteries involves reducing greenhouse gas emissions by enabling cleaner transportation options and optimized renewable energy systems. Their successful implementation could accelerate the transition to sustainable energy.

Multiple dimensions affected include environmental benefits through reduced reliance on fossil fuels, economic growth via the development of new battery technologies, and societal changes by increasing accessibility to clean transport solutions.

Notable examples include ongoing research at institutions like MIT, which focuses on overcoming current limitations of lithium-air technologies, including longevity and efficiency. Successful breakthroughs could reshape energy storage markets.

To foster lithium-air battery development, experts recommend increased funding for research, partnerships between academia and industry, and policies supporting clean energy initiatives. Coordinated efforts can help unlock battery potential.

Specific strategies include advancing materials science to improve battery components, developing new electrolytes, and enhancing battery

management systems for better performance. Such innovations can mitigate current limitations and promote widespread adoption.

How Could Lithium-Air Batteries Transform Renewable Energy Storage Solutions?

Lithium-air batteries could transform renewable energy storage solutions by providing a highly efficient and lightweight energy storage option. These batteries use lithium as the anode and oxygen from the air as the cathode. This design allows them to store significantly more energy than traditional lithium-ion batteries.

First, the energy density of lithium-air batteries is much higher. Higher energy density means that they can store more energy in a smaller space. This quality is essential for applications like electric vehicles, where weight and space are limited.

Next, lithium-air batteries can potentially reduce costs. By utilizing oxygen from the atmosphere, these batteries decrease the need for expensive materials. This reduction in material costs could lead to more affordable energy storage solutions.

Additionally, lithium-air batteries have a longer lifespan compared to conventional batteries. A longer lifespan means less frequent replacements, reducing waste and promoting sustainability. This characteristic aligns well with the goals of renewable energy, which seeks to minimize environmental impact.

Furthermore, these batteries can support intermittent renewable energy sources like solar and wind. They can store excess energy generated during peak production times and release it during periods of low production. This capability enhances the reliability of renewable energy systems.

In summary, lithium-air batteries could significantly enhance renewable energy storage by offering high energy density, cost-effectiveness, long

lifespan, and support for intermittent energy production. These features make them a promising solution for addressing the challenges in renewable energy storage.

What Is an Aluminum-Air Battery?

December 23, 2024 by [UMATechnology](#)

Aluminum-air batteries are a type of metal-air battery that uses aluminum as the anode and oxygen from the air as the cathode. These batteries are becoming increasingly popular as a potential alternative to traditional lithium-ion batteries due to their high energy density, low cost, and environmental friendliness. In this article, we will explore what aluminum-air batteries are, how they work, their advantages and disadvantages, as well as their potential applications in various industries.

1. Introduction to Aluminum-Air Batteries

Aluminum-air batteries are a type of metal-air battery that use aluminum as the anode, oxygen from the air as the cathode, and an electrolyte to facilitate the flow of ions between the two electrodes. When the battery is discharging, aluminum atoms are oxidized at the anode, releasing electrons that flow through an external circuit to power a device. At the cathode, oxygen from the air reacts with water and electrons to form hydroxide ions. These ions then migrate through the electrolyte and react with the aluminum ions at the anode to complete the circuit.

2. How Aluminum-Air Batteries Work

Aluminum-air batteries work through a series of chemical reactions that take place between the aluminum anode, oxygen from the air, and an electrolyte. When the battery is discharging, aluminum atoms at the anode are oxidized to release electrons, which flow through an external circuit to power a device. At the cathode, oxygen from the air reacts with water and electrons to form hydroxide ions, which then migrate through the electrolyte to the anode to react with the aluminum ions and complete the circuit. This process generates electricity and produces aluminum hydroxide as a byproduct.

3. Advantages of Aluminum-Air Batteries

There are several advantages of aluminum-air batteries that make them a promising alternative to traditional lithium-ion batteries. One of the main advantages is their high energy density, which allows them to store more energy per unit weight compared to lithium-ion batteries. This makes them ideal for applications where weight is a critical factor, such as in electric vehicles and portable electronics. Additionally, aluminum is abundant, cheap, and easily recyclable, making aluminum-air batteries more environmentally friendly and cost-effective than lithium-ion batteries.

Aluminum-Air Battery: How It Works, Chemistry, Applications, and Challenges

October 27, 2024 by [Ellis Gibson \(B.Sc. in Mechanical Engineering\)](#)

Aluminum air batteries are electrochemical devices. They use aluminum as the anode and oxygen from the air as the cathode. In this process, aluminum oxidizes while oxygen reduces, forming a galvanic cell. This reaction generates energy efficiently, making aluminum air batteries a sustainable option for energy sources.

In terms of applications, the aluminum-air battery can provide significant power in a lightweight form, making it ideal for use in electric cars. Additionally, it offers a potential energy solution for remote areas with limited access to traditional power sources. However, the aluminum-air battery faces several challenges. Corrosion of aluminum can lead to reduced lifespan and efficiency. Furthermore, the production of aluminum hydroxide and management of byproducts complicate recycling efforts.

Understanding the limitations of the aluminum-air battery is essential for its development. As researchers continue to innovate, these challenges may be overcome. The next discussion will explore the ongoing advancements in aluminum-air battery technology and potential future developments impacting energy storage solutions.

What Is an Aluminum-Air Battery and How Is It Different from Other Battery Types?

An aluminum-air battery is a type of electrochemical cell that generates electricity through the reaction of aluminum with oxygen from the air. This battery utilizes aluminum as the anode and typically employs a conductive electrolyte.

The U.S. Department of Energy defines aluminum-air batteries as batteries that “use aluminum as the fuel and oxygen from the air to generate electricity, making them efficient and lightweight.” They can produce high energy densities, offering significant potential for applications in electric vehicles and portable power devices.

Aluminum-air batteries operate by oxidizing aluminum, which releases electrons. The oxidation results in aluminum hydroxide and the production of electricity. Unlike conventional batteries, aluminum-air batteries are non-rechargeable; they require aluminum replacement rather than recharging.

According to the Journal of Power Sources, aluminum-air batteries exhibit theoretical energy densities of approximately 1,500 Wh/kg. This capability can provide far longer ranges for electric vehicles than many lithium-ion batteries currently available.

The broad adoption of aluminum-air batteries could reduce reliance on fossil fuels, contributing to lower greenhouse gas emissions. Their lightweight design may also enhance electric vehicle efficiency and increase range.

Aluminum-air batteries have environmental benefits, as they can use abundant aluminum instead of scarce materials. They also have the potential to lower costs and improve the economic feasibility of clean energy applications.

Adopting aluminum-air battery technology may involve enhancing battery design, increasing efficiency, and developing recycling systems for the aluminum byproducts. Experts recommend investing in research and development to overcome existing limitations.

How Does an Aluminum-Air Battery Work Mechanically and Chemically?

An aluminum-air battery works mechanically and chemically through a combination of aluminum, air, and an electrolyte. The main components include aluminum anodes, oxygen from the air, and an electrolyte, typically containing sodium hydroxide or potassium hydroxide.

Mechanically, the aluminum serves as the anode. It oxidizes and undergoes a reaction that produces aluminum ions. These aluminum ions then move into the electrolyte. The battery draws oxygen from the atmosphere, which acts as the cathode, facilitating the reduction reaction.

Chemically, at the anode, aluminum reacts with hydroxide ions in the electrolyte. This reaction produces aluminum hydroxide and releases electrons. These electrons travel through an external circuit, creating an electric current. At the cathode, oxygen from the air reacts with water and the electrons, forming hydroxide ions.

The overall reaction combines the oxidation of aluminum and the reduction of oxygen, generating electricity. This process continues until the aluminum is consumed, leading to a depletion of the battery. Thus, the aluminum-air battery functions effectively by converting chemical energy into electrical energy through these mechanical and chemical processes.

What Are the Key Components That Facilitate An Aluminum-Air Battery's Function?

The key components that facilitate an aluminum-air battery's function include the aluminum anode, electrolyte, air cathode, and separator.

1. Aluminum anode
2. Electrolyte
3. Air cathode
4. Separator

The aluminum-air battery combines these components to create a system that generates electricity through a chemical reaction with oxygen in the air. Each component plays a critical role in ensuring efficient energy conversion.

1. **Aluminum Anode:** The aluminum anode serves as the source of electrons in an aluminum-air battery. When the battery discharges, aluminum oxidizes, releasing aluminum ions and electrons. These electrons flow through an external circuit, providing electrical energy. A study by Liu et al. (2020) highlights that aluminum's high theoretical capacity of approximately 2980 mAh/g makes it an effective material for battery applications.
2. **Electrolyte:** The electrolyte facilitates the movement of ions within the battery. In aluminum-air batteries, this is typically a solution containing salt (like sodium hydroxide) that allows aluminum ions to move from the anode to the cathode. According to a paper by Zhang et al. (2019), the choice of electrolyte significantly affects the battery's efficiency and stability. Effective electrolytes reduce corrosion and improve overall energy output.
3. **Air Cathode:** The air cathode is where oxygen from the air reacts with the aluminum ions coming from the anode. This reaction produces hydroxide ions, which are crucial for maintaining the battery's charge balance. Research by Yang et al. (2021) indicates

that optimizing the cathode structure enhances oxygen diffusion, thus increasing the battery's performance.

4. **Separator:** The separator is a barrier that prevents direct contact between the anode and cathode while allowing ion flow. Its purpose is to maintain the integrity of the battery and prevent short circuits. As noted by Lee et al. (2022), a well-designed separator can enhance battery life and safety by minimizing risk from leakage or physical damage.

Together, these components create a system capable of delivering high energy density, though they also present challenges such as limited rechargeability and degradation over time. Ongoing research aims to improve the efficiency and practical applications of aluminum-air batteries in various fields, including electric vehicles and portable electronics.

What is the Electrochemical Reaction That Powers Aluminum-Air Batteries?

Aluminum-Air batteries generate electrical energy through electrochemical reactions involving aluminum and oxygen. The primary reaction occurs when aluminum reacts with oxygen from the air, resulting in the formation of aluminum hydroxide. This reaction releases electrons, which flow through an external circuit to generate power.

According to the American Chemical Society, electrochemical energy conversion is a process where chemical energy is converted into electrical energy, primarily through redox (reduction-oxidation) reactions. In aluminum-air batteries, the oxidation of aluminum and concurrent reduction of oxygen drive the electrical output.

The electrochemical reaction in aluminum-air batteries can be summarized as: $4\text{Al} + 3\text{O}_2 + 6\text{H}_2\text{O} \rightarrow 4\text{Al}(\text{OH})_3$. This indicates that aluminum (Al) is oxidized while oxygen (O₂) from the air is reduced. This type of battery is known for its high energy density and lightweight properties.

The U.S. Department of Energy describes aluminum-air batteries as having several advantages, such as longer shelf-life and lower costs, which can make them appealing for future energy storage solutions. However, their operational efficiency can be affected by factors like temperature and humidity.

Research by the U.S. Army Research Laboratory estimates that aluminum-air batteries can produce approximately 1,000 Wh/kg, significantly higher than conventional lithium-ion batteries, which average around 150 Wh/kg, suggesting strong potential for future applications in electric vehicles and portable electronics.

The development of aluminum-air batteries could reduce reliance on fossil fuels, lower greenhouse gas emissions, and promote sustainable energy use. Their potential to power vehicles shows promise for decreasing air pollution and contributing to cleaner urban environments.

Adverse consequences include the need for proper aluminum lifecycle management, as mining and production can have significant environmental impacts. Implementing recycling systems and sustainable sourcing practices can mitigate these concerns.

Examples include the development of electric vehicles using aluminum-air technology, which could lead to lower operational costs and reduced emissions compared to traditional combustion engines.

To address challenges, organizations like the International Energy Agency recommend investing in R&D for cheaper, more efficient battery production methods and promoting recycling initiatives for aluminum materials.

Innovations in battery manufacturing, like the incorporation of nanotechnology and biodegradable materials, can enhance efficiency and sustainability in the production of aluminum-air batteries. Strategic policy support and public-private partnerships can further drive advancements in this technology.

What Chemical Reactions Occur in Aluminum-Air Batteries?

Aluminum-air batteries operate through electrochemical reactions between aluminum, oxygen, and an electrolyte, producing electrical energy. The overall reaction involves aluminum oxidizing and oxygen from the air being reduced.

1. Main Reactions in Aluminum-Air Batteries:

- Oxidation of aluminum
- Reduction of oxygen
- Formation of aluminum hydroxide
- Release of electricity

The reactions in aluminum-air batteries are significant for understanding their functionality. These reactions involve the conversion of chemical energy into electrical energy through a specific process.

1. **Oxidation of Aluminum:**

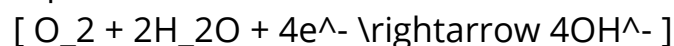
The oxidation of aluminum occurs when aluminum metal reacts with hydroxide ions in the electrolyte. This reaction forms aluminum ions and releases electrons. The oxidation reaction can be represented as follows:



This process is critical, as it provides the electrons necessary for generating electric current.

2. **Reduction of Oxygen:**

The reduction of oxygen takes place at the cathode. Oxygen from the air interacts with water and the electrons released from the oxidation of aluminum. The reduction reaction can be represented as:



This reaction consumes the electrons generated in the anode reaction, allowing the battery to sustain its operation.

3. **Formation of Aluminum Hydroxide:**

Aluminum hydroxide is produced as a byproduct of the aforementioned oxidation reaction. When aluminum ions react with hydroxide ions, they form aluminum hydroxide:



This formation plays a role in the battery's efficiency and lifespan, as aluminum hydroxide can accumulate and potentially hinder performance over time.

4. **Release of Electricity:**

The primary function of aluminum-air batteries is to release electricity through the reactions of oxidation and reduction. The electric current generated can power various devices.

Researchers emphasize the potential of aluminum-air batteries to provide longer-lasting energy compared to conventional batteries.

In summary, the chemical reactions in aluminum-air batteries primarily involve the oxidation of aluminum and the reduction of oxygen. These reactions result in both electricity generation and the formation of aluminum hydroxide. Despite their potential, aluminum-air batteries face challenges like limited cycle life and performance efficiency.

How Does Aluminum Serve as the Anode in These Batteries?

Aluminum serves as the anode in aluminum-air batteries due to its electrochemical properties. The anode is the electrode where oxidation occurs. In this context, aluminum oxidizes when it reacts with oxygen from the air. This reaction generates electricity as electrons flow from the anode to the cathode.

When the battery is in use, aluminum releases electrons, resulting in aluminum ions being formed. This process is driven by aluminum's tendency to lose electrons easily, making it a good anode material. The aluminum ions

then migrate through the electrolyte solution to the cathode. At the cathode, oxygen combines with water to create hydroxide ions, which are also involved in the overall reaction and help balance the charge.

Thus, the sequence starts with aluminum being oxidized at the anode. The electrons flow through an external circuit to the cathode and generate electric power. The overall reaction is efficient and contributes to the battery's performance. Consequently, aluminum's properties make it an effective material for anodes in this type of battery, enhancing energy density and output while being lightweight and abundant.

What Role Does Oxygen Play in the Functioning of Aluminum-Air Batteries?

Oxygen plays a crucial role in the functioning of aluminum-air batteries by serving as the primary oxidizing agent in the electrochemical reactions that generate electricity.

1. Oxygen's Role in Electrochemistry
2. Reaction Mechanism
3. Energy Density
4. Environmental Impact
5. Limitations and Challenges

Oxygen's contribution to aluminum-air batteries involves various aspects that illustrate its importance in energy conversion processes.

1. Oxygen's Role in Electrochemistry:
Oxygen's role in electrochemistry involves its function as the agent that undergoes reduction during the oxidation reactions of aluminum in aluminum-air batteries. This enables the transfer of electrons, facilitating the production of electric current. According to a study by David et al. (2021), the efficiency of the battery is closely related to oxygen's availability and concentration.

2. Reaction Mechanism:

The reaction mechanism in aluminum-air batteries is characterized by aluminum reacting with hydroxide ions in the presence of oxygen. The key reaction produces aluminum hydroxide and generates electricity. As outlined by Zhang et al. (2020), the process occurs at the anode and cathode, facilitating a continuous flow of electrons.

3. Energy Density:

Oxygen contributes to the high energy density of aluminum-air batteries, making them attractive for applications such as electric vehicles and portable electronics. Research by Li et al. (2022) indicates that aluminum-air batteries can offer energy densities up to five times greater than that of traditional lithium-ion batteries. This feature makes them a promising alternative in energy storage solutions.

4. Environmental Impact:

Using aluminum-air batteries can have positive environmental implications. Aluminum is abundant and recyclable, and the reaction produces aluminum hydroxide as a byproduct, which is less harmful than some other battery waste. The journal "Environmental Science & Technology" mentions that shifts towards aluminum-air batteries could reduce reliance on toxic materials present in conventional batteries (Chen et al., 2021).

5. Limitations and Challenges:

While oxygen is essential for aluminum-air batteries, several challenges exist. These include the limited rechargeability of aluminum anodes and the degradation of battery performance due to side reactions. Research has highlighted that improving the design and materials used can mitigate some of these issues (Kumar et al., 2023).

In summary, oxygen plays a vital role in enhancing the functionality and efficiency of aluminum-air batteries through its involvement in the

electrochemical processes, reaction mechanisms, and environmental benefits while also presenting specific limitations.

What Are the Primary Applications of Aluminum-Air Batteries in Today's Market?

Aluminum-air batteries have several primary applications in today's market, focusing on energy storage and efficiency.

1. Electric vehicles (EVs)
2. Portable power sources
3. Renewable energy systems
4. Military applications
5. Medical devices
6. Aerospace applications

These applications highlight the potential versatility and effectiveness of aluminum-air batteries. Below, I detail each application and its significance.

1. Electric Vehicles (EVs):

Aluminum-air batteries are viable for electric vehicles due to their lightweight and high energy density. In this context, aluminum serves as the anode, and a chemical reaction generates electricity as the battery discharges. Research by ZEM energy in 2022 shows that aluminum-air batteries can increase the range of EVs significantly, making them a more appealing option for consumers.

2. Portable Power Sources:

Aluminum-air batteries can be used in portable devices. Their compact design and ability to provide long-lasting energy make them suitable for powering gadgets like smartphones and laptops. Companies, such as Agave Energy, are investigating

ways to miniaturize these batteries for greater portability and efficiency.

3. **Renewable Energy Systems:**

Aluminum-air batteries can enhance renewable energy systems by storing excess energy produced by solar and wind installations. They can convert this energy into electricity when needed, increasing reliability. A study by the National Renewable Energy Laboratory in 2021 noted that integrating aluminum-air technology can improve energy storage solutions.

4. **Military Applications:**

Aluminum-air batteries offer lightweight energy sources necessary for military operations. They provide reliable power for communication and navigation equipment without adding significant weight to supplies. The Defense Advanced Research Projects Agency (DARPA) is exploring aluminum-air technology to meet military energy requirements.

5. **Medical Devices:**

Aluminum-air batteries can power medical devices, especially in remote locations. Their reliability and long lifespan offer a solution for portable medical equipment. Studies indicate that these batteries can reduce downtime, ensuring continuous operation of vital medical machinery in emergency situations.

6. **Aerospace Applications:**

Aluminum-air batteries have the potential to be used in aerospace technology due to their high energy-to-weight ratio. This characteristic is crucial for flight efficiency. NASA has been exploring aluminum-air solutions for various applications in space missions, indicating promising advancements in battery technology for the aerospace sector.

In summary, aluminum-air batteries offer diverse applications due to their advantages in energy density, weight reduction, and efficiency. Their

potential spans several industries, making them a topic of significant interest in ongoing technological research.

How Are Aluminum-Air Batteries Used in Electric Vehicles and Other Industries?

Aluminum-air batteries are used in electric vehicles and other industries primarily as energy sources. These batteries convert the chemical energy in aluminum into electricity. They utilize the electrochemical reaction between aluminum and oxygen from the air. This process generates electricity while producing aluminum oxide as a byproduct.

In electric vehicles, aluminum-air batteries can supplement traditional lithium-ion batteries. They provide a lightweight, high-energy-density option. Their low weight can enhance vehicle efficiency and increase driving range. However, they are currently limited by their inability to be easily recharged. Once the aluminum is consumed, it must be replaced rather than refilled like conventional batteries.

In other industries, aluminum-air batteries can serve in applications needing compact power sources. Their lightweight and high efficiency make them suitable for drones, portable electronics, and backup power systems. Despite their advantages, challenges like the need for aluminum recycling and the management of oxygen intake persist. These factors impact the overall feasibility and adoption of aluminum-air batteries in various sectors.

What Challenges Do Aluminum-Air Batteries Face in Terms of Viability and Adoption?

Aluminum-air batteries face several challenges that hinder their viability and widespread adoption. These challenges include technical limitations, economic considerations, and regulatory barriers.

1. Technical limitations
2. Energy density vs. energy efficiency
3. Cost of materials and production
4. Environmental concerns
5. Lack of infrastructure
6. Competition from other battery technologies
7. Regulatory and safety issues

Addressing these challenges is crucial for improving the outlook for aluminum-air batteries.

1. **Technical Limitations:** Technical limitations refer to the current performance gaps in aluminum-air batteries. They generally provide high theoretical energy density but suffer from practical issues such as limited rechargeability and instability during operation. According to a 2020 study by Peled et al., the recharging cycle can exhibit poor recharge efficiency, leading to diminished capacity over time.
2. **Energy Density vs. Energy Efficiency:** Energy density vs. energy efficiency describes the trade-off between the amount of energy stored and how effectively it can be utilized. Aluminum-air batteries can outperform conventional batteries in energy density but may fall short in energy efficiency. A report from the U.S. Department of Energy (DOE) highlights that while aluminum-air batteries possess the potential for high capacity, this does not always translate into practical application due to lower cycling efficiency.
3. **Cost of Materials and Production:** The cost of materials and production affects feasibility. While aluminum is abundant and inexpensive, the processes needed to manufacture aluminum-air batteries can be costly. Research from the University of Michigan (2021) indicates that higher production costs diminish the competitive advantage of aluminum-air batteries compared to lithium-ion alternatives.

4. **Environmental Concerns:** Environmental concerns involve the impacts of aluminum extraction and disposal of used batteries. The mining process for aluminum can be ecologically damaging. Additionally, improper disposal of aluminum-air batteries may lead to environmental hazards. A study from the Global Environmental Change journal (2022) raises concerns regarding the lifecycle environmental impact of these batteries.
5. **Lack of Infrastructure:** The lack of infrastructure refers to the insufficient support systems required for widespread adoption. Unlike lithium-ion batteries, which have established recycling and refueling stations, aluminum-air battery adoption may be limited by the absence of such facilities. A 2019 analysis by energy consultancy Navigant Research emphasizes that infrastructure development is crucial for enhancing battery performance and user acceptance.
6. **Competition from Other Battery Technologies:** Competition from other battery technologies presents a significant challenge. Lithium-ion batteries continue to dominate the market due to their maturity and extensive research, leaving little room for aluminum-air batteries to penetrate. An industry report by BloombergNEF (2021) highlights that advancements in lithium-ion technology, with improvements in performance and cost, overshadow potential aluminum-air innovations.
7. **Regulatory and Safety Issues:** Regulatory and safety issues involve compliance with safety standards and regulations for new battery technologies. Concerns regarding the flammability of certain materials and the potential for battery failures must be addressed. The International Energy Agency (IEA) emphasizes the need for robust regulations to ensure the safety and sustainability of energy storage systems, including aluminum-air batteries.

In summary, while aluminum-air batteries hold promise, addressing these challenges is necessary for improving their viability and promoting their adoption.

What Are the Performance Limitations and Environmental Concerns Associated With Aluminum-Air Batteries?

Aluminum-air batteries face certain performance limitations and environmental concerns. These issues include efficiency challenges, material sourcing, waste generation, and potential pollution.

1. Performance Limitations:
 - Limited energy efficiency
 - Low power output
 - Degradation over time
 - Inability to be recharged easily
2. Environmental Concerns:
 - Resource extraction impacts
 - Waste disposal issues
 - Pollution from battery materials
 - Lifecycle environmental footprint

These performance limitations and environmental concerns lead to ongoing debates about the viability of aluminum-air battery technology.

1. Performance Limitations:

Performance limitations in aluminum-air batteries impede their commercial applications. Limited energy efficiency refers to the lower energy yield compared to conventional batteries. Studies reveal that these batteries typically achieve about 40-60% energy efficiency, resulting in less usable power (Davis, 2020).

Low power output restricts rapid discharge capabilities, making them unsuitable for high-demand applications like electric vehicles. The

degradation over time affects the battery's reliability, as the aluminum anode corrodes and loses functionality. Additionally, aluminum-air batteries currently cannot be easily recharged, which diminishes their practicality. They often require complete replacement once depleted, creating a continuous cycle of use and disposal.

2. Environmental Concerns:

Environmental concerns regarding aluminum-air batteries raise questions about their sustainability. Resource extraction impacts are significant, as aluminum mining can lead to habitat destruction and ecological imbalance. According to the International Aluminum Institute (IAI), the extraction process is energy-intensive and has a substantial carbon footprint.

Waste disposal issues arise because aluminum-air batteries can produce a significant volume of hazardous waste when discarded. Pollution from battery materials can occur during manufacturing and disposal, potentially contaminating soil and water sources. The lifecycle environmental footprint, considering production, use, and end-of-life, requires careful assessment and management.

Addressing these challenges needs a multi-faceted approach involving improved designs, recycling mechanisms, and sustainable sourcing practices. Continued research and innovation could pave the way for more sustainable and efficient aluminum-air battery solutions.

Scientists Built the Battery That Will Finally Unlock Massless Energy Storage

- Scientists have made a [massless structural battery](#) 10 times better than before.
- The battery cell performs well in structural and energy tests, with planned further improvements.
- Structural batteries reduce weight and could revolutionize [electric cars](#) and planes.

In groundbreaking research, scientists have [made a structural battery](#) 10 times better than in any previous experiment.

What's a structural battery, and why is it such a big deal? The term refers to an energy storage device that can also bear weight as part of a structure—like if the studs in your home were all batteries, or if an electric fence also held up a wall.

In the [paper](#), researchers from Chalmers University of Technology and KTH Royal Institute of Technology in Sweden reveal how their “massless” structural battery works.

The main use case is for electric cars, where a literally massive amount of batteries take up a ton of room and don't contribute to the actual structure of the car. In fact, these cars must be specially designed to carry the mass of the batteries.

But what if the frame of the car could hold energy? “Due to their multifunctionality, structural battery composites are often referred to as ‘massless energy storage’ and have the potential to revolutionize the future design of electric vehicles and devices,” the researchers explain.

To make the structural battery, the scientists layered a buffer glass “fabric” between a positive and negative electrode, then packed it with a space-age polymer electrolyte and cured it in the oven. What results is a tough, flat battery cell that conducts well and holds up to tensile tests in all directions.

The battery's combined qualities (or "multifunctionality") make it 10 times better than any previous massless battery—a project scientists have worked on since 2007.

Chalmers University of Technology writes in a [press release](#):

"The battery has an energy density of 24 Wh/kg, meaning approximately 20 percent capacity compared to comparable lithium-ion batteries currently available. But since the weight of the vehicles can be greatly reduced, less energy will be required to drive an electric car, for example, and lower energy density also results in increased safety. And with a stiffness of 25 GPa, the structural battery can really compete with many other commonly used construction materials."

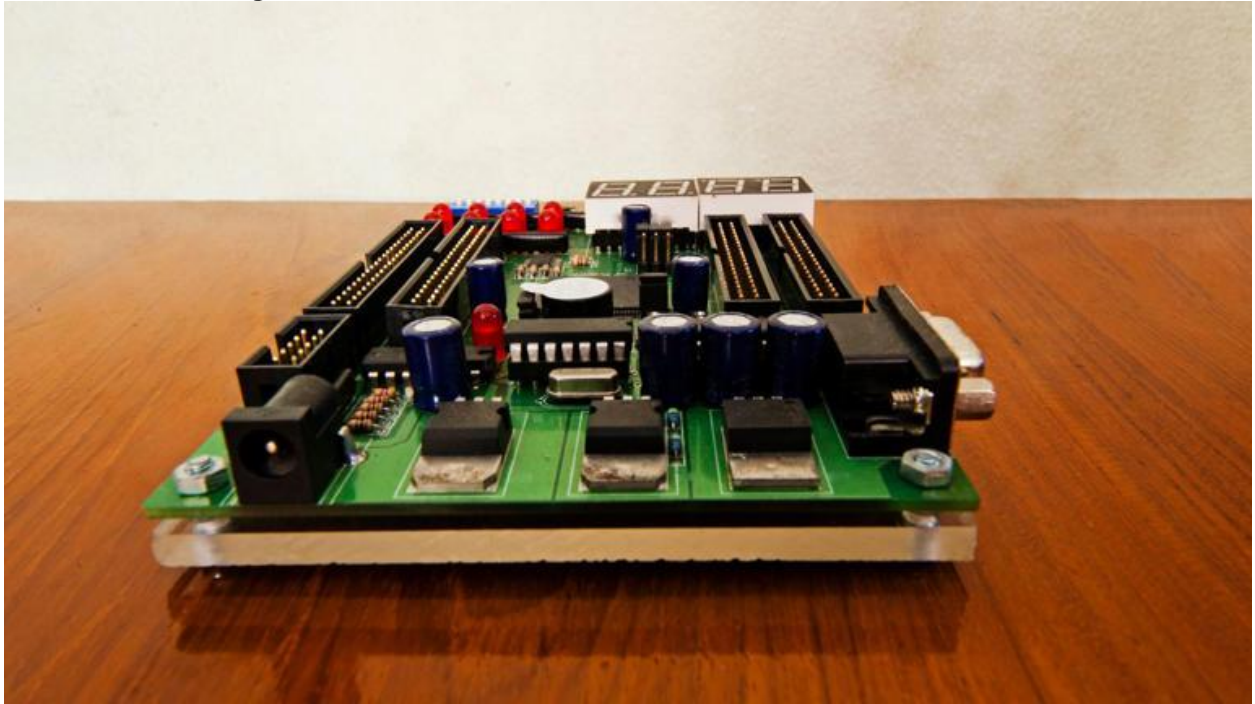
The scientists say the next step is to improve the performance even more, replacing aluminum foil in the electrode with carbon fiber material and thinning out the separator. This could result in a battery that produces 75 Wh/kg of energy and 75 GPa of stiffness, setting more records for massless batteries and also greatly reducing their weight.

Besides electric cars, the study team mentions [e-bikes](#), satellites, and laptops as technologies that could use massless batteries. There could be further applications that we don't think of as electric at all today.

One of the most exciting potential uses is in aircraft, which scientists are struggling to turn electric because of the huge weight of existing battery tech. Regular airplanes as well as vertical take off and landing vehicles could turn

electric by using massless batteries. They could even combine massless structural batteries with solar panels in order to store what they soak up for later use.

World's 1st self-charging supercapacitor harnesses solar energy with 63% efficiency



World's 1st self-charging supercapacitor harnesses solar energy with 63% efficiency

A collaborative research team has unveiled a high-performance self-charging energy storage supercapacitor that efficiently captures and stores solar energy, a significant advancement for sustainable energy.

This innovative technology combines supercapacitors and solar cells, marking a milestone in energy storage developments.

The groundbreaking study, published in the journal *Energy*, highlights how the research team has enhanced the capabilities of existing supercapacitors.

Self-charging supercapacitor

By employing composite materials made from nickel-based carbonates and hydroxides, they achieved impressive results in energy efficiency.

The team incorporated various transition metal ions, including manganese (Mn), cobalt (Co), copper (Cu), iron (Fe), and zinc (Zn), to boost the conductivity and stability of the electrodes.

The results of this research are compelling. The new energy storage device boasts an energy density of 35.5 watt-hours per kilogram (Wh kg^{-1}), significantly surpassing figures reported in earlier studies, which typically ranged from 5 to 20 Wh kg^{-1} .

Furthermore, the power density achieved is an impressive 2555.6 watts per kilogram (W kg^{-1}), far exceeding previous benchmarks of around 1000 W kg^{-1} .

Such capabilities enable the device to deliver high power rapidly, allowing for an immediate energy supply, especially for devices requiring power bursts.

Another key feature of this innovation is its durability. The device exhibits minimal performance degradation after numerous charge and discharge cycles, indicating its long-term viability.

This resilience makes it a promising option for real-world applications.

In addition to its impressive storage capabilities, the research team has successfully created a hybrid energy storage device that integrates silicon solar cells with supercapacitors.

63% efficiency

This combination allows the system to store and utilize solar energy in real time. Impressively, the hybrid system achieved an energy storage efficiency of 63%, alongside an overall efficiency of 5.17%.

These advancements suggest a bright future for commercializing self-charging energy storage solutions.

"This study represents a significant achievement, as it introduces Korea's first self-charging energy storage device that seamlessly integrates supercapacitors with solar cells," Jeongmin Kim, a Senior Researcher at the Nanotechnology Division of DGIST, emphasized the importance of this development, said.

"By leveraging transition metal-based composite materials, we've addressed the limitations of traditional energy storage technology and offered a sustainable energy solution."

Damin Lee, a researcher at the Renewable Energy Laboratory of Kyungpook National University, added, "Our team is committed to conducting follow-up research to further enhance the device's efficiency and unlock its full commercialization potential."

The development of this self-charging energy storage device comes at a crucial time as the world moves toward cleaner energy solutions.

This new technology enhances energy storage capabilities and paves the way for more efficient solar energy use, aligning with global efforts to [reduce](#) carbon emissions and promote sustainability.

As researchers continue to refine this technology, the potential applications for self-charging devices are vast, from powering homes to supporting electric vehicles.

The future of energy storage looks promising with the developments emerging from this innovative collaboration.

In conclusion, this breakthrough represents a significant stride toward achieving efficient, sustainable energy solutions supporting consumer needs and broader environmental goals.

The collaboration between these research institutions signifies a hopeful path forward in pursuing advanced energy technologies.

EV Battery Breakthrough May Prevent Fires Entirely

Korean researchers have developed a fireproof lithium metal battery with a solid electrolyte.

- Researchers are racing to develop battery chemistries that can prevent electric vehicle fires.
- Battery scientists in Daegu, South Korea developed a chemistry where the pack might be able to extinguish itself in case of a fire.
- The lithium metal battery uses a solid polymer electrolyte with a fire-resistant layer.

After a string of electric vehicle [fire incidents](#) in South Korea last year that caused nationwide panic and skepticism regarding EVs, battery safety research appears underway in full swing in the country.

EV fires are [statistically rarer](#) than gas car fires, but they grab more headlines given how new the technology really is. In the rare instances when EV fires do occur, the batteries burn gradually, become more intense and are painful to extinguish due to [thermal runaway](#), a phenomenon causing lithium-ion cells to burn uncontrollably for hours.

But battery scientists are inching closer to developing chemistries that can prevent EV fires altogether. A study published in academic journal [Small](#) explains how the potentially fireproof battery works.

A research team at the Daegu Gyeongbuk Institute of Science and Technology has developed a lithium metal battery that has a longer lifespan compared to traditional lithium-ion batteries and may also extinguish fires by itself thanks to a specially developed electrolyte—the material that allows the free flow of electrons between the battery’s positive and negative terminals.

The scientists developed a “triple layer solid polymer electrolyte” that could prevent fires and facilitate rapid movement of charge-carrying ions within the

cells, which translates to faster energy transfer rates. After 1,000 charging and discharging cycles, the lithium metal battery retained nearly 88% of its original capacity.

"This research is anticipated to make a significant contribution to the commercialization of lithium metal batteries using [solid polymer] electrolytes, while providing enhanced stability and efficiency [to] energy storage devices," principal researcher of the study Dr. Kim Jae-hyun said in a press release.

Applications of such a battery can be wide-ranging, as per the study. If at all the technology gets commercialized, it can be used in everything from smartphones to wearables and EVs to large-scale energy storage systems.

Korean battery giant [LG Energy Solution](#) has also developed EV batteries that can suppress thermal runaway. It revealed last year a temperature sensitive "safety reinforced layer" in battery packs that acts as a "fuse" to prevent overheating in the first place.

We explain in our [EV Myths Discharged](#) series how gas cars are several times more likely to engulf in flames compared to EVs. Yet, the focus on EV fire safety continues to increase, which is only a good thing.

Of course, these fire prevention mechanisms are in the early stages of research and development. And there may not be a silver bullet to entirely prevent EV fires just yet. But with the U.S. and global EV markets growing to new heights every year, expect this tech—or something similar—to be commercially deployed sooner than later.

World's largest EV battery maker unveils 373-mile-range swappable batteries

Contemporary Amperex Technology Co. Limited (CATL), the world's largest manufacturer of batteries for electric vehicles and energy storage, has unveiled two types of swappable batteries and rolled out a charging network with 100 partners in China, a press release said.

Founded in 2011, CATL is the battery provider for the likes of Tesla, BMW and Volkswagen to name a few of the leading electric vehicle makers. The company isn't just assembling batteries for these brands but providing the technology for the most important component of their EVs.

CATL's technological expertise is much superior to that of battery manufacturers located elsewhere in the world and has helped address concerns of range among potential EV buyers.

Interesting Engineering has previously reported how the company's recent achievements, including fast-charging batteries, could herald a new era in the EV sector. Now, the company is rolling out swappable batteries as it believes, it will maximize the value of each battery.

Paying as per usage

According to Yang Jun, the CEO of CATL's battery swapping arm, [CAES](#), the EV industry will see a shift wherein users will not buy the entire battery pack. Instead, people will prefer to pay for their usage of the battery pack, which will also help maximize the value of each battery.

With this in mind, CATL is working on the Choco-swap ecosystem, where users will be able to swap batteries on their vehicles in about 100 seconds.

At its conference last month, the company launched two versions of its swappable batteries, dubbed #20 and #25, much like #92 and #95 versions of gasoline available at gas stations.

Both #20 and #25 are available in lithium-iron-phosphate (LFP) and ternary versions with capacities ranging from 42 kWh to 70 kWh. They have a range

between 248 – 372 miles (400 – 600 km) and will be available for vehicles of class A0 and A/B.

The company also announced that all its batteries developed in the future would be compatible with the swappable approach.

The road ahead

At the conference, Jun explained that China's 100,000 gas stations would eventually be replaced by equal proportions of public and private charging stations and [battery-swapping](#) centers.

With this in mind, plans to build an initial network of 1,000 Choco-Swap stations by 2025 and expand into Hong Kong and Macau. Over the years, it will increase this number to 10,000 stations with the ultimate aim of building 30,000 battery s When ready, these stations will not only serve customers by providing them with charged batteries, but they will also serve as distributed energy storage units for a battery-to-grid system. With each station hosting 14-30 battery packs, the swap stations alone will serve as a store of 33.6 million kWh of green electricity.

CATL will use its advanced technology for battery monitoring to ensure optimal battery usage and maximize the value of each battery. With the battery swapping model rolled out, CATL is also working with car makers and financial institutions to make it easy to buy, use, and replace cars without any hassles.

"Battery swapping is not only CATL's endeavor but also the endeavor of everyone who wants to promote sustainable development. We hope to bring together more forces through the Choco-Swap ecosystem to jointly promote the prosperous development of the battery swapping industry," added Robin Zeng, CEO of CATL at [the event](#).

Researchers achieved stunning results after transforming common waste into vital material for futuristic batteries: 'Opening up new possibilities'



While lithium-ion batteries have great energy density ... supercapacitors are more adept at rapid charging and energy delivery.

The development of efficient [energy storage](#) solutions is key to our sustainable energy future, and a recent study has shown that waste oil can be repurposed to help support that goal.

Researchers from Tongji University and the University of Shanghai for Science and Technology have introduced an innovative method for transforming oil into high-quality electrode materials essential in building supercapacitors, as Tech Xplore [detailed](#).

Supercapacitors have the ability to charge and discharge energy very quickly without substantially affecting long-term performance, something that can be difficult for today's [lithium-ion batteries](#).

However, Tech Xplore noted there have been challenges in meeting the growing demand for the high-quality materials needed to build supercapacitors, as they require a balance of conductivity and surface area.

To resolve this, the outlet explained, scientists have explored "advanced carbon materials with intricate porous structures and strategically placed nitrogen atoms, a process known as heteroatom doping," and waste oil is a great source.

"By using waste oil as a precursor, we're not only [recycling](#) waste into a valuable resource but also creating a supercapacitor material with exceptional electrochemical properties," Dr. Suyun Xu, a leading researcher on the project, said.

"Our approach optimizes the pore structure and uses nitrogen doping to elevate the performance of supercapacitors, opening up new possibilities for sustainable, high-efficiency energy storage."

While lithium-ion batteries, such as those used to [power electric vehicles](#), have great energy density, supercapacitors are more adept at rapid charging and energy delivery in short bursts, [according to](#) Futurebridge. That's why [some automakers](#) employ them to handle the energy input from regenerative braking and deliver it to help boost acceleration in some EVs and fuel-cell hybrids.

Supercapacitors have been found to recover [53%](#) more energy from braking than traditional batteries, which helps boost the overall efficiency of EVs. This also lowers the [heat burden](#) on lithium-ion batteries, helping to extend their lifespan.

New donut-shaped in-wheel motor could make EVs lighter, increase range

Electric motor manufacturer Donut Lab has shown off its latest innovation at [CES 2025](#).

The company's second-generation in-wheel drive units could drastically alter the way electric vehicles are designed.

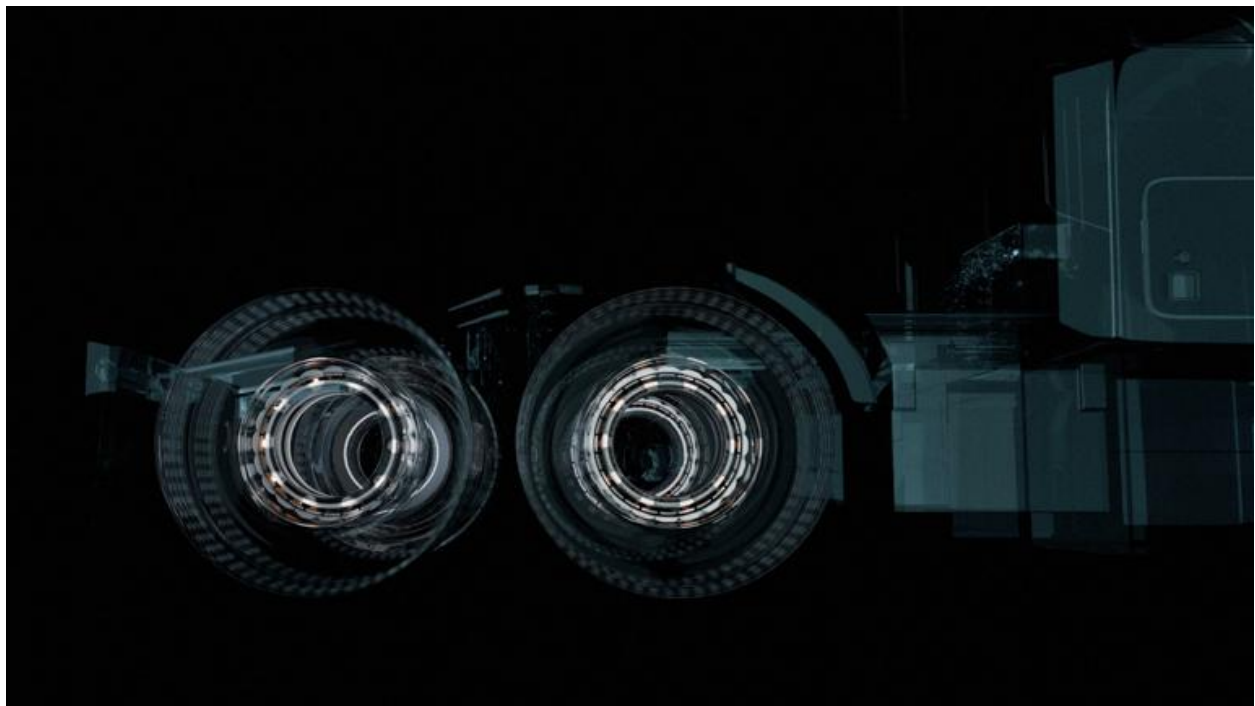
The new motor seemingly draws inspiration from the company's namesake – a big hole in the middle allows it to fit perfectly into a wheel. According to Donut Lab, this will reduce a lot of weight, while providing great gains in power and torque.

Donut Lab's new in-wheel motor

To date, the EV industry has taken a great deal of inspiration from the design of internal combustion engine (ICE) vehicles. That's logical, given the fact that EVs are an iteration of ICE vehicles. That familiarity in design can also help with global EV adoption, which slowed down [slightly](#) in 2024.

However, electric motors allow for far greater design adaptability than ICEs. Case in point: Donut Lab's second-generation donut-motor. The in-wheel design means no motor is housed in the vehicle's body. This frees up space, allowing for more seating area and cargo capacity.

It could ultimately allow for some pretty wild designs, resembling some of the [crazy concept vehicles](#) often on display at trade shows.



A render representing Donut Lab's in-wheel motor technology. Source: Donut Lab

Donut Lab says its second-generation donut motor fits into a 21-inch hoop. It delivers a performance of up to 630 kilowatts (845 horsepower) and 4,3000 newton-meters (3,171 pound-feet of torque) per unit. Impressively, the motor weighs only 88 pounds (40 kg). According to a report from [CNET](#), that's equivalent to roughly a third of a traditional rotor-and-stator electric drive unit.

Lowering weight is crucial to increasing EV range. While EVs will require more than one of Donut Lab's motors, the resulting removal of drivetrain components, half-shafts, and other parts will result in even greater weight savings.

New in-wheel motor is 50% cheaper to manufacture

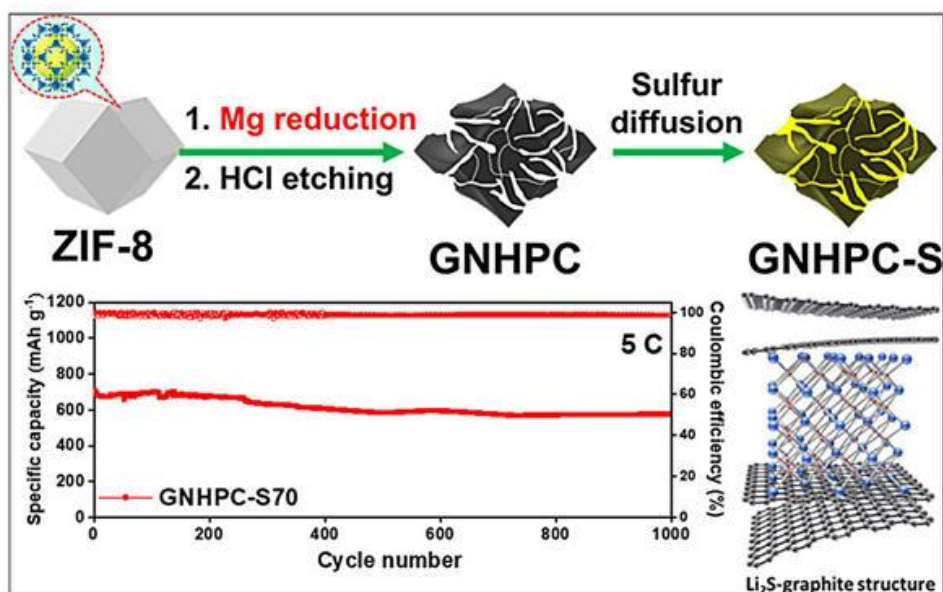
Donut Lab also says its motors are up to 50 percent cheaper to manufacture. This is largely down to the fact they use fewer parts, the company says. This could ultimately result in more affordable EVs.

However, questions do remain over the performance of Donut Lab's in-wheel motors. While they reduce overall weight, they are heavier than conventional wheels. This means they add unsprung mass – weight below the suspension – which can negatively affect handling and braking.

Aside from its new 21-inch in-wheel motor, Donut Lab also revealed a new semi-truck version of its in-wheel motor. This will provide 200 kW and 2,212 lb-ft (3,000 Nm) per wheel. The company's in-wheel motor technology is already used on the road on a few electric bikes developed by its [parent company](#), Verge Motorcycles.

Donut Lab isn't the only company experimenting with in-wheel motors. Last year, BMW announced it had developed its own in-wheel electric motor in partnership with Munich-based tech firm DeepDrive. That motor features a unique [dual-rotor design](#) and is currently in the testing phase.

Fully charged in just 12 minutes: Next-gen lithium–sulfur battery retains 82% capacity after 1,000 cycles



Credit: ACS Nano (2024). DOI: 10.1021/acsnano.4c09892

A research team has developed an innovative technology to dramatically improve the charging speed of lithium–sulfur batteries. The team used a new nitrogen-doped porous carbon material to address the slow charging speed issue that has hindered the commercialization of existing lithium–sulfur batteries.

Lithium–ion batteries are indispensable for eco-friendly technologies such as electric vehicles. Despite being limited by low energy storage capacity and high costs, they have gained attention as next-generation batteries due to their high energy density and the low cost of sulfur as a material. Still, commercialization has been challenging due to insufficient sulfur utilization during rapid charging, which reduces battery capacity.

Another issue is the lithium polysulfides produced during the discharge process. These compounds migrate within the battery, degrading its performance. To address this, researchers have been developing batteries by incorporating sulfur into porous carbon structures. However, they have yet to achieve performance levels suitable for commercialization.

To solve these challenges, Professor Jong-sung Yu of the DGIST team synthesized a novel highly graphitic, multiporous carbon material doped with nitrogen and applied it to the cathode of a lithium–sulfur battery. This technology successfully maintained high energy capacity even under rapid charging conditions. The research is [published](#) in the journal *ACS Nano*.

The newly developed carbon material was synthesized by employing a thermal reduction method that involves magnesium and ZIF-8, a metal-organic framework. At high temperatures, magnesium reacts with the nitrogen in ZIF-8, making the carbon structure more stable and robust while creating a diverse pore structure. This structure not only allows for higher sulfur loading but also improves the contact between sulfur and the electrolyte, significantly enhancing battery performance.

The lithium–sulfur battery developed in this study utilized the multifunctional carbon material synthesized, through the simple magnesium-assisted thermal reduction method, as a sulfur host. Even under rapid charging conditions with a full charge time of just 12 minutes, the battery achieved a high capacity of 705 mAh g⁻¹, which is a 1.6-fold improvement over conventional batteries.

Furthermore, nitrogen doping on the carbon surface effectively suppressed lithium polysulfide migration, allowing the battery to retain 82% capacity even after 1,000 charge–discharge cycles, demonstrating excellent stability.

During the research, the collaborative team, led by Dr. Khalil Amine of Argonne National Laboratory, performed advanced microscopic analyses. These analyses confirmed that lithium sulfide (Li₂S) was formed in a specific orientation within the layered structures of the newly developed carbon material. This finding validated that nitrogen doping and the porous carbon structure enhanced sulfur loading, while the graphitic nature of the carbon accelerated sulfur reactions, thereby improving charging speed.

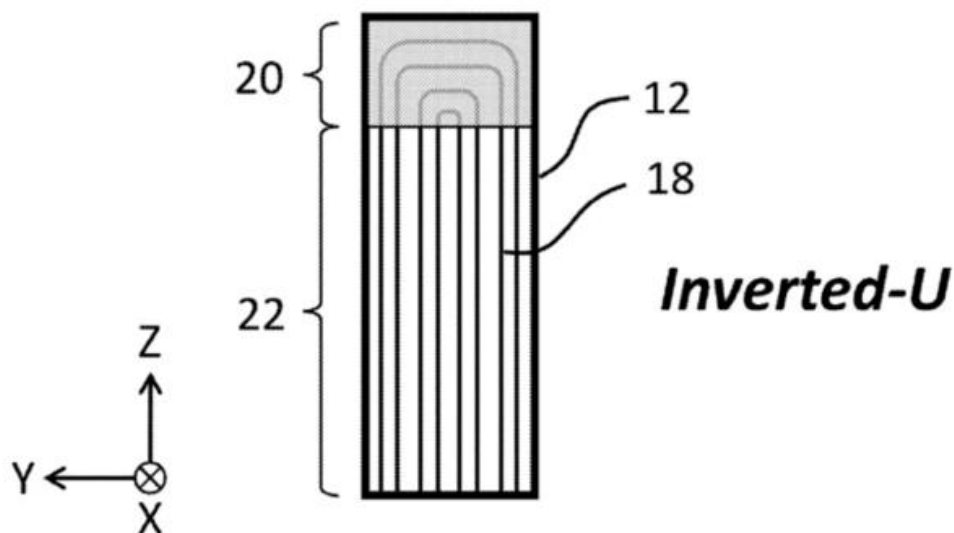
Professor Yu remarked, "This research focused on improving the charging speed of lithium–sulfur batteries using a simple synthesis method involving magnesium. We hope this study will accelerate the commercialization of lithium–sulfur batteries."

More information: Jeong-Hoon Yu et al, Tailoring-Orientated Deposition of Li₂S for Extreme Fast-Charging Lithium–Sulfur Batteries, *ACS Nano* (2024). DOI: [10.1021/acsnano.4c09892](https://doi.org/10.1021/acsnano.4c09892)

Provided by Daegu Gyeongbuk Institute of Science and Technology

GM Innovates in Batteries: The Future of Cooling in Prismatic Cells

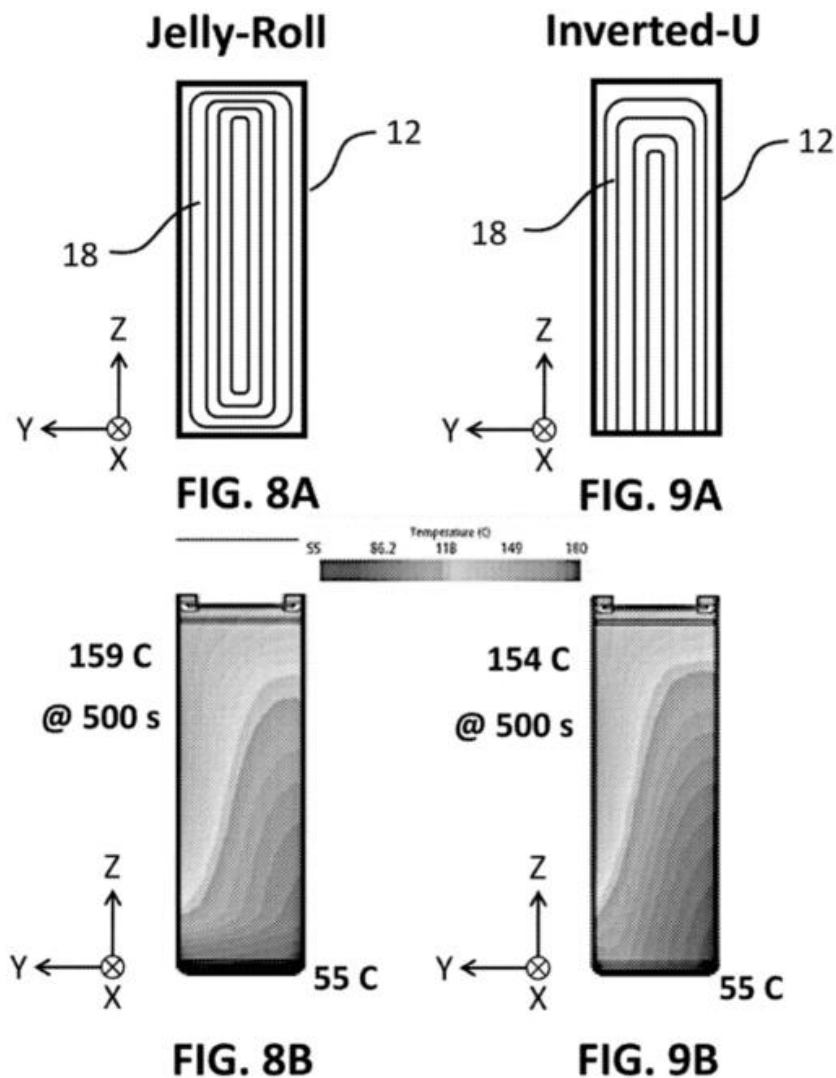
General Motors (GM) has unveiled a groundbreaking patent for prismatic battery cell design that promises to redefine the cooling standard in electric vehicles. According to the details in the patent published by the United States Patent and Trademark Office, GM proposes an inverted "U" stacking. This design allows for greater thermal conductivity both horizontally and vertically, significantly improving heat dissipation in the cells.



Patent submitted by GM. Source: Green Car Reports.

Additionally, **this configuration slows down heat propagation within the cells and keeps maximum temperatures lower.** This not only increases battery

safety but also enables the creation of thinner thermal barriers, increasing the space available for active materials and, consequently, energy density.



Patent submitted by GM. Source: Green Car Reports.

The innovative design also paves the way for more compact batteries, as it reduces the need for bulky cooling systems. However, its complex shape could present manufacturing challenges, which explains why other manufacturers have yet to adopt similar approaches.

With this patent, **GM reaffirms its commitment to flexibility in using cell formats—including cylindrical, prismatic, and pouch—for its electric vehicles.** While brands like Tesla and BMW continue to bet on cylindrical cells, GM is forging ahead with its own solutions that could make a difference in range, efficiency, and compact design in the coming years.

This development not only strengthens GM's position in the electric vehicle market but also promises to set new standards in battery technology. What do you think about this patent?

New coating keeps EV batteries stronger, with 94% capacity after 100 cycles

Lithium-ion batteries are important for reducing carbon emissions. For decarbonization, researchers are actively working to enhance the performance of these batteries.

Researchers at the Paul Scherrer Institute (PSI) have developed a new process to boost the electrochemical performance of lithium-ion batteries used in electric vehicles.

This process helps to increase the operating voltage of the batteries.

“If the voltage increases, the energy density also increases,” said Mario El Kazzi from the PSI.

The team developed a new surface coating for high-voltage cathodes that allows operation up to 4.8 volts.

New protective coating

Lithium-ion batteries work by moving lithium ions between the cathode and anode. To increase energy density, we need to operate them at higher voltages.

However, higher voltages can damage the cathode, leading to reduced battery life.

Operating lithium-ion batteries above 4.3 volts triggers significant degradation at the cathode-electrolyte interface. This leads to increased resistance and reduced capacity. As a result, commercial batteries are currently limited to a maximum operating voltage of 4.3 volts.

The team developed a novel approach to stabilize the cathode surface using a thin, uniform coating.

For the protective coating, the research utilizes trifluoromethane (CHF₃), a by-product of plastic manufacturing. At 572 degrees Fahrenheit (300°C), CHF₃ reacts with the lithium carbonate layer on the cathode, converting it into lithium fluoride (LiF).

The researchers conducted high-voltage electrochemical tests to determine the coating's effectiveness.

The results demonstrated the coating's stability, enabling operation at voltages as high as 4.5 and even 4.8 volts while effectively protecting the [cathode](#) material.

Furthermore, the team found that coated batteries outperformed those with unprotected cathodes across all key metrics.

For instance, impedance, the resistance to [lithium-ion](#) movement at the cathode interface, was 30 percent lower after 100 cycles in coated batteries.

"This is a clear sign that our protective layer minimizes the increase in resistance caused by the interfacial reactions that would otherwise occur," added El Kazzi.

High capacity retention

The team also evaluated capacity retention, a key metric indicating the battery's ability to sustain its energy storage capacity throughout numerous charge-discharge cycles. High capacity retention indicates sustained energy delivery after repeated use.

The coated cathode significantly outperformed the uncoated one in this regard. It maintained over 94 percent of its initial capacity after 100 cycles, while the uncoated battery retained only 80 percent.

This new coating process has the potential to significantly increase the energy density of a wide range of battery types.

“We can assume that our lithium fluoride protective coating is universal and can be used with most cathode materials. For example, it also works with nickel- and lithium-rich high-voltage batteries,” said El Kazzi in the [press release](#).

Trifluoromethane is a potent greenhouse gas with a significant environmental impact. This new process provides a valuable solution by effectively utilizing CHF₃ to create a protective coating for battery cathodes.

This approach improves battery performance and simultaneously mitigates environmental impact by preventing the release of harmful gases. This contributes to a more sustainable and circular economy.

The study was originally published in the journal [ChemSusChem](#).

Single-Crystal Batteries Could Power EVs for Millions of Miles

Electric cars already have [comparable range](#) to gasoline and diesel cars, but batteries have an extra problem: they degrade in time. Now, a new study led by researchers from Dalhousie University in Canada suggests there could be a better way. The researchers found that “single-crystal electrodes” could power electric vehicles (EVs) for millions of miles over decades. In other words, EV battery degradation would no longer be a practical concern.

The electrification of our transportation and [energy systems](#) depends on reliable, long-lasting batteries. In fact, batteries are one of the biggest bottlenecks slowing down this transition. [Lithium-ion batteries](#) have revolutionized energy storage, but their performance declines after years of use.

By US law, the lithium-ion batteries powering EVs on the road need to be able to hold 80% of their original [full charge](#) after 8 years in operation. Many scientists feel like that’s not enough. If batteries could last for decades, it would be a game changer not just for cars, but for our electricity use as well. Used batteries could get a second life in grid energy systems, storing wind or [solar energy](#).

This is where single-crystal electrode batteries come in.

These batteries use materials composed of individual, large crystalline structures, while traditional batteries typically consist of aggregated polycrystalline particles. In the new study, a team led by Toby Bond assessed the durability of commercial, single-crystal batteries. The researchers found them to be much more durable than conventional batteries.

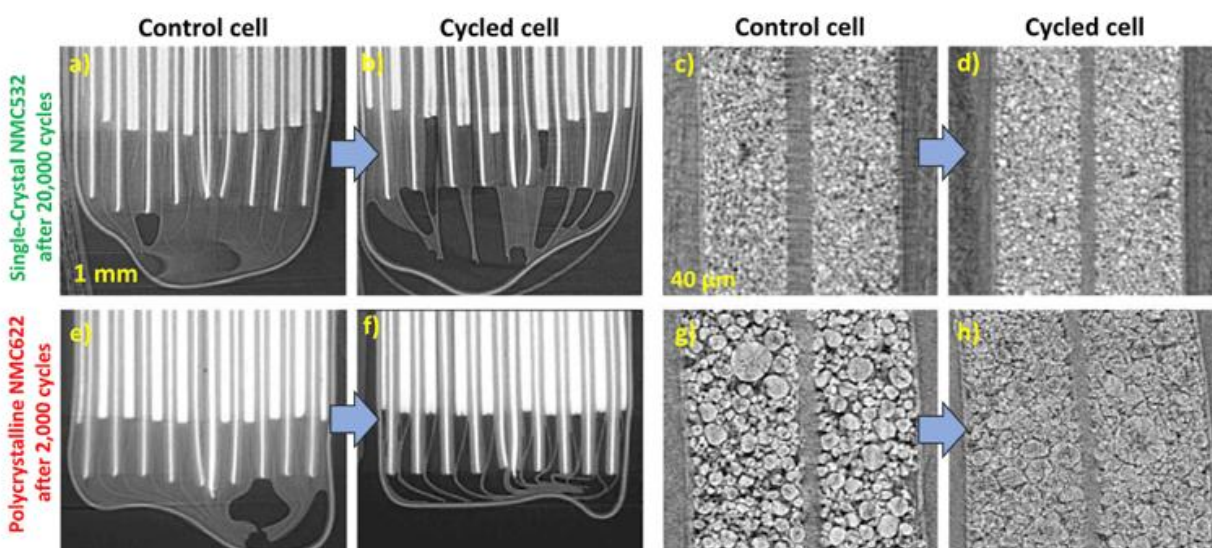
Durable, single-crystal batteries

The single-crystal battery was extensively cycled over six years, completing more than 20,000 cycles, equivalent to 8 million kilometers of EV use. After all this, it was at 80% capacity — the capacity conventional [EV batteries](#) typically reach after 2,400 cycles. After 2.5 years, the single-crystal batteries retained 96% of their capacity.

The researchers also characterized what happens inside the batteries as they suffer wear and tear in realistic conditions.

"The main focus of our research was to understand how damage and fatigue inside a battery progresses over time, and how we can prevent it," says Toby Bond.

High-resolution computed tomography (CT) scans revealed extensive cathode microcracking in heavily cycled cells. The charging and discharging of the battery essentially force the lithium atoms in the battery material apart. This causes expansion and contraction of the material, which results in cracks. "Eventually, there were so many cracks that the electrode was essentially pulverized," Bond [says](#).



Comparison of CT data for the single-crystal (top, NMC532) cycled over 20,000 times and the polycrystalline (bottom, NMC622) cell cycled 2380 times. Image credits: Bond et al (2024). © ZME Science

These cracks disrupt the electrode's structural integrity, reducing active material and creating dead zones where lithium ions can no longer flow. Single-crystal cathodes, by comparison, exhibited far less cracking, reinforcing their potential for more durable batteries. "In our images, it looked very much like a brand-new cell. We could almost not tell the difference."

The research also suggests that surface coatings and electrolyte additives can mitigate degradation. Alumina coatings and carefully selected additives were shown to slow the degradation. Notably, partial-depth cycling (up to 25% DoD)

also reduces degradation compared to full-battery cycling, which suggests that charging the battery more often can be a good idea.

The technology already exists

The good news is that this type of battery is already here. It's not commonly used in [electric cars](#) and its production is not scaled, but the technology does exist. This new study just described a better methodology to assess how well it works.

The researchers emphasize the importance of studying commercial cells under realistic conditions (as was done here). By using real-world commercial cells rather than lab-constructed ones, the study ensured that the results applied to actual usage conditions. While lab-built cells provide useful data, they often fail to replicate the nuanced degradation patterns seen in the field.

"I think work like this just helps underscore how reliable they are, and it should help companies that are manufacturing and using these batteries to plan for the long term," Bond adds.

From single-crystal cathodes to optimized cycling strategies, the insights gained from this work are good news for our goal of a more sustainable, electrified world. As these findings make their way into commercial applications, the promise of more efficient and durable EV batteries comes closer to reality.

"We really need these vehicles to last as long as possible, because the longer you drive them, the better its improvement on the [carbon footprint](#) is," says Bond.

The study "The Complex and Spatially Heterogeneous Nature of Degradation in Heavily Cycled Li-ion Cells" [was published](#) in the Journal of the Electrochemical Society.

Scientists make first-of-its-kind discovery on quest to create safer EV batteries — here's what they found

Battery enthusiasts should be ready to dig deep into their chemistry books for a full view of the [latest findings](#) coming out of the Tokyo University of Science.

While the complicated research hasn't produced a fully working battery, it could provide game-changing insight into the creation of a key power pack part: the negative electrode. Eventually, the analysis may help to produce a better [electric vehicle](#) pack with a precise electrode analysis method, all according to a report [published](#) by EurekAlert.

Battery innovations are happening around the world, including with tech that revives Thomas Edison-era iron-alkaline science.

Battery enthusiasts should be ready to dig deep into their chemistry books for a full view of the [latest findings](#) coming out of the Tokyo University of Science.

While the complicated research hasn't produced a fully working battery, it could provide game-changing insight into the creation of a key power pack part: the negative electrode. Eventually, the analysis may help to produce a better [electric vehicle](#) pack with a precise electrode analysis method, all according to a report [published](#) by EurekAlert.

When lithium-ion batteries [cycle](#), ions move between two electrodes — the anode and the cathode — through a substance called electrolyte. The team is interested in finding a better alternative to commonly used carbon negative electrodes, or cathodes. Carbon is subject to troublesome [dendrite](#) formation when quickly charged, which in turn can cause a short circuit and fire, as described by the lab [summary](#) and [ScienceDirect](#).

While [rare](#), lithium-ion battery fires can be [catastrophic](#).

In response, the Japanese experts investigated [transition metal oxides](#) as an alternative to carbon. The oxide-based materials have great thermal stability and other attributes that promote better fire safety. A promising type is called Wadsley-Roth phase oxides, including TiNb_2O_7 , or TNO, all [per](#) EurekAlert.

"The network structure of TNO forms lithium-ion conduction pathways and has a significant influence on the properties of negative electrodes," research team lead and associate professor Naoto Kitamura said in the report.

But the material's atomic structure needed to be charted. To accomplish the task, the team analyzed three unique samples. One was pristine, one was [ball-milled](#) to reduce its particle size, and one was heat-treated, [according](#) to the lab notes.

A series of advanced tests, including topological analysis, revealed that ball milling followed by heat treatment produced the best results for charge-discharge performance, the report continued.

"For the first time, we could prove that the combination of intermediate-range structure and topology analyses is a promising way of developing a guideline for improving electrode properties," Kitamura said, per EurekAlert.

Battery [innovations](#) are happening around the world, including [tech](#) that revives [Thomas Edison](#)-era [iron-alkaline](#) science and promising [solid-state](#) power packs. Often, the goal is to increase EV range, charge speeds, and safety while lowering costs.

That's important, because each EV that replaces a gas-burning car prevents thousands of pounds of harmful, heat-trapping exhaust annually, as [noted](#) by the U.S. Department of Energy.

Curbing the fumes is a goal drivers of all vehicles can help to achieve. [Efficient driving habits](#) can stack up to more than a hundred bucks in savings a year via shorter routes and less idling time. Reducing planet-warming fume production is also a lung-friendly move, as medical experts have [linked](#) the gases to a range of health risks, including carcinogen exposure.

For now, the researchers are confident that their findings will lead to better-performing lithium-ion batteries, which would be a boon to EVs and other tech.

"TNO can be used in lithium-ion batteries for cars and can contribute to the green growth strategy for achieving carbon neutrality," Kitamura [said](#).

Electric vehicles (EVs) are rapidly becoming a cornerstone of sustainable transportation. They promise reduced greenhouse gas emissions and lower reliance on fossil fuels. However, EVs are not without risks, one of the most concerning being the potential for their batteries to catch fire or explode.



It's Rare, But It Happens

While instances are rare compared to internal combustion engine (ICE) vehicles, the severity and visibility of such events make them noteworthy. Let's look at the reasons behind these incidents and examine the science and engineering challenges involved.



The Science Behind Battery Explosions

Most electric vehicles use **lithium-ion (Li-ion) batteries**, renowned for their high energy density and efficiency. However, this high energy density also makes them susceptible to thermal runaway, a phenomenon where an increase in temperature causes a chain reaction, leading to overheating and, in extreme cases, fire or explosion.

1. Thermal Runaway:

- When a Li-ion battery cell overheats, it can trigger a domino effect. This process begins with one cell, which transfers heat to adjacent cells, potentially leading to a catastrophic event.
- Causes of thermal runaway include overcharging, physical damage, or internal short circuits.

2. Internal Short Circuits:

- Manufacturing defects or damage from external impacts can cause the electrodes inside a battery cell to touch. This results in an internal short circuit, generating excessive heat.

3. Overcharging:

- Overcharging can degrade the electrolyte within the battery, releasing flammable gases that can ignite if exposed to a spark.

4. **Electrolyte Composition:**

- Li-ion batteries use a flammable electrolyte. If the battery casing is compromised, the electrolyte can leak, potentially causing fires when it contacts oxygen.
-



External Factors Contributing to Battery Fires

While the intrinsic properties of Li-ion batteries play a significant role, **external factors** can also contribute to explosions or fires.

1. **Vehicle Accidents:**

- High-speed collisions can puncture or deform battery packs, leading to short circuits or exposure of the flammable electrolyte to air. For example, a Tesla Model S caught fire in Florida in 2019 after crashing into a tree.

2. **Exposure to Extreme Conditions:**

- Excessive heat can degrade battery components, increasing the likelihood of thermal runaway. Conversely, freezing conditions can cause dendrite formation, leading to internal short circuits.

3. **Improper Charging Practices:**

- Using non-standard chargers or leaving the vehicle charging unattended for extended periods can lead to overheating and potential fire risks.



Mitigating Risks: Advances in Technology and Safety Measures

© Frame Stock Footage via Shutterstock.

Manufacturers and researchers are actively addressing the risks associated with EV batteries. Several strategies are being developed and implemented to enhance safety:

1. **Battery Management Systems (BMS):**

- Modern EVs are equipped with sophisticated **BMS** that monitor and regulate charging, discharging, and temperature. These

systems can detect anomalies early and prevent catastrophic failures.

2. **Improved Battery Designs:**

- Solid-state batteries, currently under development, use solid electrolytes instead of flammable liquid ones, significantly reducing fire risks.
- Reinforced battery casings and advanced cooling systems help mitigate the effects of thermal runaway.

3. **Crash-Test Standards:**

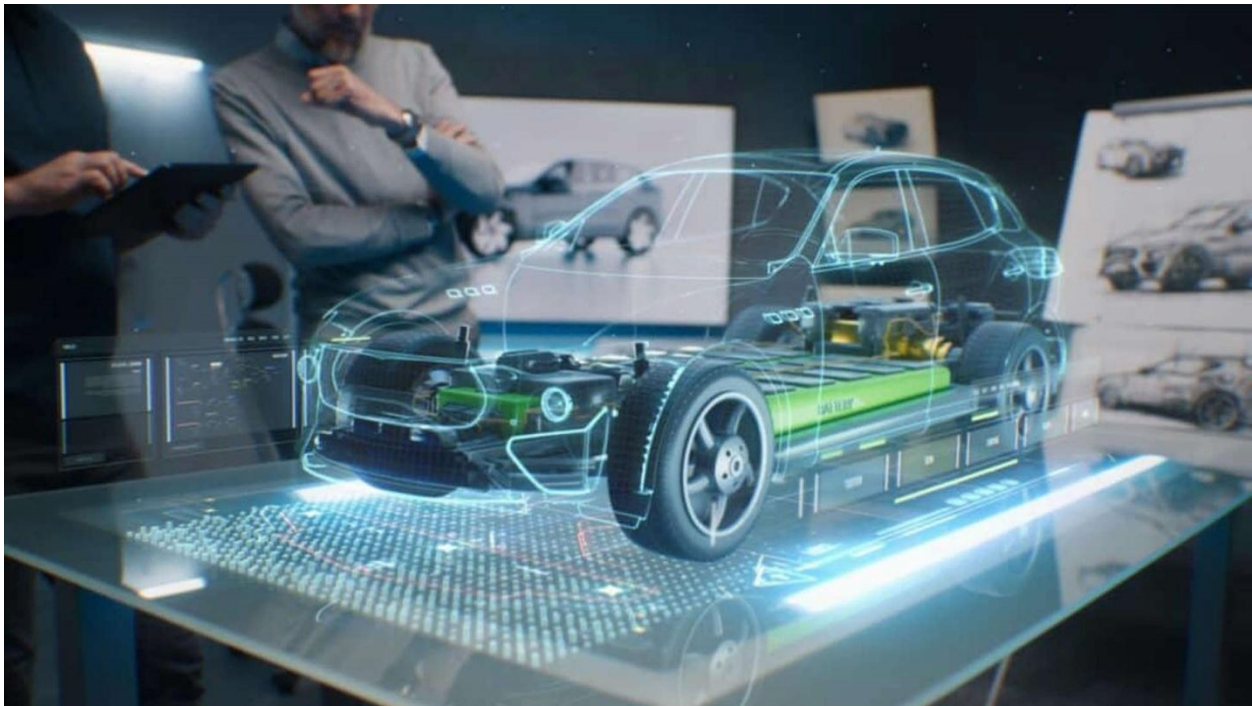
- Regulatory bodies have introduced stringent crash-test requirements for EVs to ensure that battery packs can withstand severe impacts.

4. **Charging Infrastructure:**

- The proliferation of standardized charging equipment with built-in safety features, such as surge protection, has reduced the risk of overcharging and overheating.

5. **Early Detection Systems:**

- Emerging technologies, such as thermal imaging and gas sensors, can detect early signs of thermal runaway, allowing for timely intervention.



Comparison with Internal Combustion Engine Vehicles

It's essential to contextualize the risk of EV battery fires against traditional ICE vehicles. According to the [National Fire Protection Association \(NFPA\)](#), over 170,000 highway vehicle fires occur annually in the U.S., most of which involve gasoline-powered cars. Studies suggest that EVs are statistically less likely to catch fire than ICE vehicles, but their fires often receive more attention due to the novelty and intensity of such incidents.

Lessons from Aviation and Energy Sectors

© Sergey Denisenko via Shutterstock.

The aviation and energy industries, which also rely on Li-ion batteries, offer valuable lessons:

1. Aviation:

- Incidents involving laptop or smartphone batteries overheating on flights have led to strict regulations on transporting Li-ion batteries.
- The Boeing 787 Dreamliner faced [grounding in 2013 due to battery fires](#), prompting design changes.

2. Energy Storage:

- Large-scale energy storage systems have experienced fires, such as the 2019 Arizona battery storage facility incident. Lessons from these events are being applied to improve EV battery safety.

Conclusion

While the risk of EV battery explosions or fires cannot be entirely eliminated, advancements in technology, stricter regulations, and lessons from real-world incidents are significantly reducing these occurrences. EVs are generally **safer** and more environmentally friendly than ICE vehicles when considering their overall lifecycle impact. By addressing the challenges associated with Li-ion batteries, manufacturers can ensure a safer and more sustainable future for transportation.

Breakthrough EV battery may have the power to extinguish its own fires: 'A significant contribution'

The [description](#) of a triple-layer polymer electrolyte being developed at a lab in South Korea at times calls to mind a candy bar. It has a "soft outer surface" and a "robust middle layer."

While absent a creamy caramel center, the crucial battery component could provide better fire safety — as it can extinguish its own flames — as well as have greater longevity than other packs. Those are important metrics for battery developers in the effort to provide a cheaper, better-performing unit, all [according](#) to a lab report from the Daegu Gyeongbuk Institute of Science and Technology.

"This research is anticipated to make a significant contribution to the commercialization of lithium metal batteries using [solid polymer] electrolytes, while providing enhanced stability and efficiency [to] energy storage devices," principal researcher Kim Jae-hyun said.

The battery includes two promising technologies. It's a [lithium metal](#) pack, using lithium as an anode material instead of [graphite](#). Lithium metal offers reliable, long-lasting, and high-capacity storage. But the [tech](#) suffers some problems during operation that have limited its use, all per ScienceDirect. For its part, graphite is subject to sometimes troublesome foreign [supply chains](#).

Secondly, solid electrolytes are being developed by experts at [Harvard University](#) and elsewhere because of better fire safety, reliability, and longevity, according to ScienceDirect. High cost, and the absence of a scalable manufacturing process, are some of the [cons](#) highlighted by Top Speed.

When batteries operate, ions move between the anode and cathode through the electrolyte, regardless if it's a solid or liquid, as [detailed](#) by the U.S. Department of Energy.

DGIST's triple-layer electrolyte could solve some of the problems that have held the tech back as a mainstream power source for [electric vehicles](#), smartphones, and even large-scale energy storage.

A key [problem](#) with conventional solid polymer electrolytes is [dendrite](#) formation. These metal, branch-like structures grow inside batteries as they cycle, causing shorts.

As part of the triple-layer approach, the Korean electrolyte includes [decabromodiphenyl ethane](#), a flame retardant, for self-extinguishing fire safety. Conflagrations are a concern for common lithium-ion packs. The flammable components can be a part of [terrible](#) blazes and explosions, though they are [rare](#).

DGIST also added [zeolite](#) to provide strength. Lastly, a heavy dose of lithium salt ensures ions are moving well, all per DGIST.

The pack performed strongly during testing. The different layers worked to boost mechanical strength and electrode contact, leading to an 87.9% performance retention after 1,000 cycles. That's an improvement over the 70% to 80% mark notched by most common packs, all according to the lab summary.

Batteries continue to set impressive milestones as EVs and energy storage play bigger roles in our cleaner energy and [transportation](#) systems. Each [EV](#) that replaces a gas-burning car [prevents](#) thousands of pounds of air pollution a year, per U.S. government data.

Big batteries such as [Tesla's Megapack](#) are already storing intermittent [renewable energy](#) for later use, supporting the grid during peak demand.

It's all part of the way we can reduce troublesome [heat-trapping](#) air pollution, [linked](#) by NASA to increased risks for severe weather and even [wildfires](#). University of California, Los Angeles, climate scientist David Swain told [NBC News](#) that our changing climate is contributing to dry vegetation during winter along with high winds. The combination is part of the reason the deadly Palisades Fire in Los Angeles was so terrible.

Even small steps to reduce planet-warming fumes can make a difference. Try unplugging unused chargers and devices. In addition to saving energy, you can cut your power bill by up to [\\$165](#) a year.

US designs powerful electrolyte to boost lithium-sulfur battery life, energy, efficiency

Researchers have advanced lithium-sulfur (Li-S) batteries with innovative electrolyte additives to solve key challenges associated with them.

Li-S batteries face challenges like poor electrolyte wetting and slow ion transport in thick sulfur cathodes, especially under practical conditions.

The new study reveals that a Lewis acid additive (LAA), previously thought unsuitable, can form a uniform interphase layer within the cathode, enhancing ion transport.

Using advanced techniques and simulations, researchers validate this approach, offering new insights into electrolyte-cathode interactions and paving the way for improved Li-S battery performance.

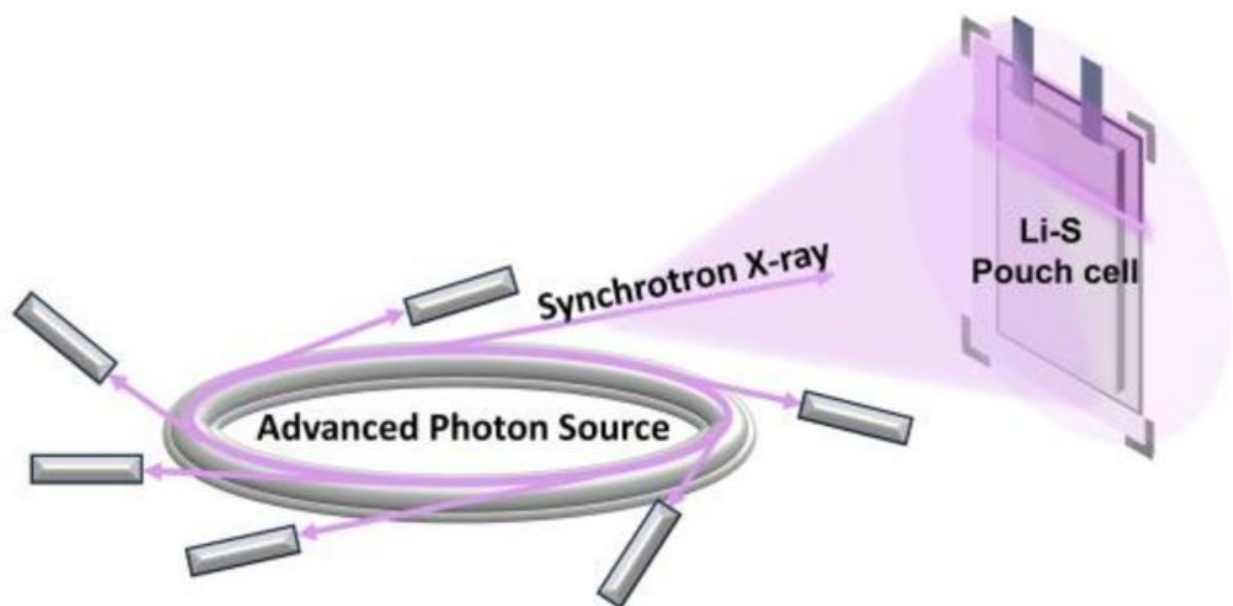
The team at the US Department of Energy's (DOE) Argonne National Laboratory (ANL) claims that the new electrolyte design can improve energy density, reduce cost, and increase cycle life.

Advancing Li-S batteries

As the world becomes more electrified, scientists from all over the world are vying to create even better "beyond Li-ion" batteries, despite the fact that Li-ion batteries have so far been a huge success.

Commercial Li-ion batteries use relatively costly materials like cobalt and nickel compounds, which are also highly dependent on unstable supply chains, and have a lower energy density than alternative batteries.

Li-S batteries, which feature a sulfur cathode and a lithium metal anode, are among the most viable substitutes for Li-ion batteries. This electrode combination uses resources that are readily available on Earth and promises two to three times higher energy densities and lower costs.



A schematic depiction of the synchrotron X-ray experiment was used in this research to study the Li-S battery cell.

Lithium-sulfur batteries face challenges like short cycle life caused by polysulfide migration and uneven chemical reactions. Unlike Li-ion batteries, which store lithium ions between cathode layers, Li-S batteries rely on chemical reactions where sulfur converts into soluble polysulfides.

According to researchers, this causes a “shuttling” effect, depositing material at the anode and reducing performance. Strategies to address this include electrolyte additives, previously considered incompatible due to their chemical reactivity with the sulfur cathode and other battery components.

Stable lithium solutions

To tackle these challenges, the ANL team developed a new class of additives that enhance battery performance. By carefully managing the additives’ interaction with sulfur compounds, researchers successfully created an improved interface between the cathode and electrolyte, enabling smoother lithium-ion transport.

“The additive, called a Lewis acid additive, is a salt that reacts with the polysulfide compounds, forming a film over the entire electrode. The key is to have a minor reaction to form the film, without a continuous reaction that consumes the

material and reduces energy density,” said Guiliang Xu, ANL chemist and the research lead, in a statement.

The additive forms a protective film on the anode and cathode, suppressing the shuttle effect, stabilizing the cell, and promoting efficient [ion](#) transport. This electrolyte design minimizes sulfur dissolution and improves reaction uniformity, allowing the use of previously incompatible additives.

Researchers compared the new electrolyte with a conventional one, observing significantly reduced polysulfide formation and dissolution, confirmed through advanced [X-ray](#) techniques. By tracking reactions during charging and discharging, the findings demonstrated that the electrolyte design effectively mitigates polysulfide shuttle issues.

The team claims the improved interface also enhances ion transfer, reducing reaction inconsistencies and addressing key challenges in lithium-sulfur battery performance.

“With further optimization and development of sulfur electrodes, we believe Li-S batteries can achieve higher energy [density](#) and better overall performance, contributing to their commercial adoption,” said Xu, in a [statement](#).

Lithium metal stability and safety still remain major challenges for Li-S batteries due to their reactivity and electrolyte flammability. Researchers are developing safer, more stable electrolytes.

Advanced X-ray techniques at ANL’s Advanced Photon Source, including absorption spectroscopy, diffraction imaging, and fluorescence mapping, revealed polysulfide solubility, cell reaction uniformity, and sulfur migration, offering insights to address these issues and improve battery performance.

The details of the team’s [research](#) were published in the journal *Joule*.

Scientists discover key material that could unlock next-gen EV batteries: 'A game changer'



It's still a great time to switch to an EV, a move that can save you up to \$1,500 or more a year on gas/maintenance costs.

Experts from the University of Houston who are part of an international team of scientists have developed an impressive [component](#) that can boost sodium-ion battery performance by 15%.

The sodium superionic conductors are aptly named, as they let sodium ions move smoothly as the pack charges and discharges, [according](#) to a news release from the Houston lab.

However, the lack of a well-established supply chain for the parts to make them is among the hurdles, all according to [GEP](#), a New Jersey supply chain/procurement company not involved with the Houston research.

"Sodium is nearly 50 times cheaper than lithium and can even be harvested from seawater, making it a much more sustainable option for large-scale energy storage," Houston Assistant Professor Pieremanuele Canepa [said](#) in the lab summary. "Sodium-ion batteries could be cheaper and easier to produce, helping

reduce reliance on lithium and making battery [technology](#) more accessible worldwide."

The conductor is made from sodium vanadium phosphate. The researchers said in the report that it has greatly boosted [energy density](#), or power storage per pound, making sodium packs competitive with lithium ones.

Lithium batteries are a common power source in [electric vehicles](#), smartphones, and other devices. The costly components are subject to [foreign](#) supply chains, which can be problematic. Invasive, [dirty](#) mining and production processes are also needed to gather and refine the metals used to make the packs.

Still, even the dirtiest batteries are [better](#) than fossil fuels, especially when powering an EV, as [explained](#) by the Massachusetts Institute of Technology. That's because [far less](#) — billions of tons — battery materials are pulled from the Earth each year than for nonrenewable resources, [per](#) Sustainability by Numbers. And the energy releases no planet-warming fumes.

In fact, each EV [prevents](#) thousands of pounds of air pollution annually when compared to a gas-burning vehicle, according to a government report. Sodium-based [batteries](#) are promising alternatives to common lithium-ion packs because they use more common, less expensive materials. They can also potentially charge faster, among other performance perks.

The reduced pollution can improve our atmosphere, as exhaust, smog, and other burnt-fuel pollution lead to increased risks for lung and heart disease, as well as cancer, [according](#) to medical experts at the World Health Organization.

Sodium-ion tech is being developed as a cleaner solution in multiple labs with great results. For example, a large storage pack in China is [operational](#), holding enough energy to power 12,000 homes.

At Houston, the conductor has proved that it can accommodate stable charge/discharge cycling at a competitive voltage rate, an important milestone that the scientists noted.

"The continuous voltage change is a key feature," Canepa [said](#) in the summary. "It means the battery can perform more efficiently without compromising the electrode stability. That's a game changer for sodium-ion technology."

The experts added that the [findings](#) could be used to help improve other battery chemistries, as well.

"Our goal is to find clean, sustainable solutions for energy storage," Canepa said in the Houston [report](#).

What's more, it's still a great time to [switch](#) to an EV, a move that can save you up to \$1,500 or more a year on gas/maintenance costs. Tax [credits](#) and valuable incentives from certain brands, including [Ford](#), remain available to make the rides more affordable.

'SK On' Inches Closer To Making Solid-State Batteries A Commercial Reality

Solid-state batteries are essentially the holy grail of [electric vehicle](#) energy storage. With a different internal design than conventional lithium-ion cells, solid-state packs promise greater safety, faster charging, and higher energy density, all with a much longer lifespan. These are huge upsides to be certain, but the problem is these batteries are still largely in the laboratory, under development. Fortunately, things are moving forward. Last week, South Korean battery company SK On announced some development breakthroughs as it works to commercialize solid-state technology.

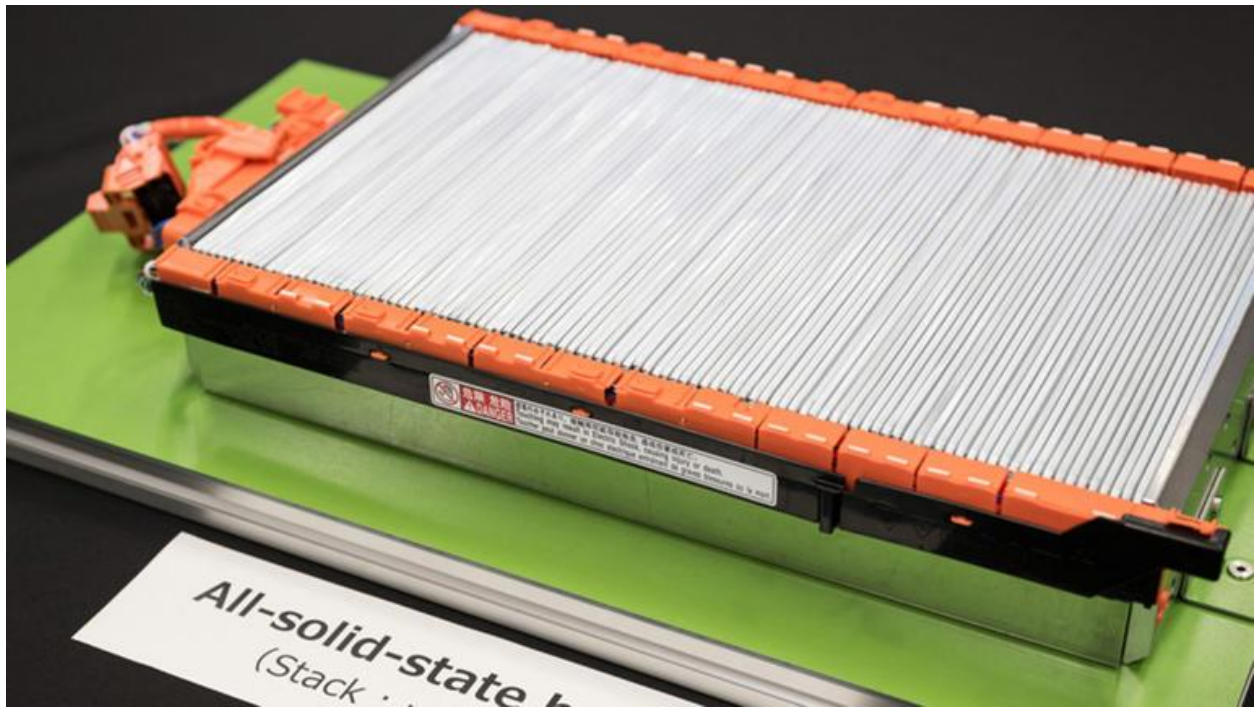


Discussion

Are You Optimistic About Solid-State Batteries?

We keep hearing about solid-state batteries and their importance to the EV industry. We also know a number of automakers are hoping to deploy them by the end of the decade. Do you think they'll be the big breakthrough many hope they'll be? Will they just be the next incremental step toward better battery performance? Or will they be a big disappointment — a case of over-promising and under-delivering?

Photonic Sintering And New Battery Designs



Toyota© Provided by TopSpeed

Before diving into the technical details, a brief explanation of what solid-state batteries are is probably warranted. According to a media release from [SK On](#), solid-state cells “replace the liquid electrolytes found in conventional lithium-ion batteries with solid electrolytes,” hence the name. “These solid electrolytes are broadly categorized into sulfide-based, oxide-based, and polymer-based types.”

As the company points out, oxide-based electrolytes are challenging to work with, requiring heat treatment at more than 1,832 degrees Fahrenheit (1,000 Celsius) for more than 10 hours, which adds to production costs, but this is not the only pitfall. These electrolytes are also susceptible to brittle fractures, cracks that form without significant distortion. According to SK On, these fissures make it difficult to scale up solid-state batteries.

New Techniques Speed Up The Process



Nissan

Addressing the manufacturing issues associated with oxide-based electrolytes, the company is developing a technology called photonic sintering, "A process that uses intense light energy applied instantaneously to strengthen the bonding of powder particles, resulting in a solid mass with enhanced strength, durability and improved material properties." This promises to improve the production of solid electrolytes. According to SK On, this process is ultra-fast and heat treatment temperatures are low, speeding up manufacturing.

Aside from improved production methods, the company is also developing two types of solid-state battery: polymer-oxide composite and one that's sulfide-based. For the former design, commercial prototypes are expected to come out in 2027, though the latter won't debut until two years later. SK On is building a solid-state battery pilot factory in South Korea. This facility is expected to be completed in the second half of the year.

Solid-State Batteries Could Spark An EV Revolution

Numerous companies and automakers are hard at work developing solid-state batteries, and [this includes Toyota](#). The Japanese company is aiming to commercialize this groundbreaking technology by 2027 or '28.

In a release published by the automaker in 2023, [Toyota estimates its first solid-state battery](#) design will increase the driving range of an electric vehicle by a whopping 20% to around 621 miles (1,000 km). Additionally, DC fast charging from a 10 percent state of charge to 80 percent is expected to take 10 minutes or less. More advanced battery designs could also boost vehicle range by 50 percent, an absolutely staggering increase.

Solid-state technology could spark an EV revolution. With greater range, batteries can be made smaller, lighter, and potentially much more affordable. With incredibly speedy charging, many of the downsides inherent to today's electric cars and trucks could be eliminated by solid-state batteries.

Breakthrough plastic supercapacitor hits 70,000 charge cycles, offers 100x conductivity



Researchers at UCLA have developed a new method for growing PEDOT nanofibers with exceptional energy storage capabilities.

"The advance could lead to supercapacitors that can meet some energy storage demands as the world transitions to renewable, sustainable energy production," said the researchers in a press release.

"Better supercapacitors are one route to reduced dependence on fossil fuels."

It can have potential applications in hybrid and electric vehicles, portable electronics, and renewable energy systems.

PEDOT, an abbreviation for poly(3,4-ethylenedioxythiophene), belongs to a class of plastics known as conductive polymers, which can conduct electricity.

"It is also found in touch screens, organic solar cells and electrochromic devices, such as smart windows that switch from light to dark at the press of a button," [added](#) the researchers.

Overcoming limitations in PEDOT

However, its use in energy storage has been limited due to the low conductivity and surface area of commercially available PEDOT.

The UCLA team overcame these limitations by developing a unique vapor-phase growth process that produces vertical PEDOT nanofibers, resembling dense grass.

"The material's unique vertical growth allows us to create PEDOT electrodes that store far [more energy](#) than traditional PEDOT," said Maher El-Kady, corresponding author and UCLA materials scientist.

"Electric charge is stored on the surface of the material, and traditional PEDOT films don't have enough surface area to hold very much charge. We increased the surface area of PEDOT and thereby increased its capacity enough to build a supercapacitor."

Supercapacitors store energy by accumulating electrical charge on their surface, allowing for rapid charging and discharging. This makes them ideal for applications requiring quick "bursts of power," such as regenerative braking in electric vehicles.

However, it has been challenging to create materials with sufficient surface area to hold large amounts of energy.

"This increased surface area is crucial because it allows for much more energy to be stored in the same volume of material, significantly boosting the [performance](#) of supercapacitors," highlighted the press release.

Exceptional performance of UCLA's PEDOT nanofibers

The UCLA team's PEDOT nanofibers demonstrate exceptional performance in this regard. These nanofibers exhibit a conductivity 100 times higher than commercial PEDOT products and an electrochemically active surface area four times greater than traditional PEDOT.

This translates to a charge storage capacity of more than 4600 milliFarads per square centimeter, significantly higher than conventional PEDOT.

Moreover, the material demonstrated exceptional durability, lasting through more than 70,000 charging cycles.

“The exceptional performance and durability of our electrodes shows great potential for graphene PEDOT’s use in supercapacitors that can help our society meet our energy needs,” commented Richard Kaner, corresponding author of the study.

This breakthrough holds significant implications for the future of energy storage. The development of high-performance PEDOT nanofibers could lead to more efficient supercapacitors.

This, in turn, can enable faster charging electronics, longer-range electric vehicles, and improved renewable energy storage solutions.

US firm unveils 'transformative' battery that could solve major issue with EVs: 'A significant leap forward'



The benefits of this new battery technology could be wide-reaching.

A U.S.-based battery maker has achieved a breakthrough that could finally make all solid-state batteries a reality. According to [Interesting Engineering](#), Microvast has developed a solid-state battery that can reach voltages unheard of in traditional lithium-ion batteries, while also being safer.

This could have a huge impact on the [electric vehicle](#) industry. The lithium-ion batteries used in most EVs today have their limitations. They have limited range, they can take too long to charge, and [they can be a fire risk](#), although still [less of a fire risk](#) than gas-powered vehicles.

But the battery developed by Microvast should eliminate each one of those issues. There's no longer a fire risk because solid-state batteries use a solid electrolyte rather than the liquid electrolytes used in lithium-ion batteries. These batteries will also have a higher energy density, meaning longer range and faster charging times.

Maybe most impressive is the higher voltage. Most lithium-ion battery cells operate at voltages [between 3.2V and 3.7V](#). The battery cells developed by Microvast, however, can operate at voltages [between 12V and 21V](#).

"The absence of liquid electrolytes ensures our batteries can operate at voltages unattainable by conventional designs, underscoring the transformative potential of our [technology](#)," [said](#) Microvast chief technology officer Wenjuan Mattis.

"Our solid-state battery innovation represents a significant leap forward in addressing real-world safety and efficiency challenges," [said](#) Microvast CEO Yang Wu. "By developing a technology that eliminates liquid electrolytes and prioritizes scalability, we are well-positioned to meet the evolving needs of industries requiring reliable and safe energy storage solutions."

The benefits of this new battery technology could be wide-reaching. For starters, by eliminating the issues some people might have with current EV batteries, it could convince some would-be car buyers to [make their next vehicle an EV](#).

Enough people making the switch to EVs would greatly decrease the amount of [carbon pollution](#) entering the atmosphere, leading to the [overheating](#) of the planet and [extreme weather events](#) that [threaten lives](#) and the [global food supply](#). That's not even to mention the [health risks](#) posed by the pollution created by gas-powered vehicles.

But these batteries will have more applications than just for EVs. Microvast will be able to make batteries to meet specific energy and spatial needs, so their batteries could be used in a variety of industries, further eliminating dependence on [dirty energy](#) sources.

Microvast is now moving into the pilot production phase to continue to develop and scale the technology.

Other organizations are working to perfect solid-state technology as well. Researchers at Harvard recently developed a solid-state battery that can be [recharged in only 10 minutes](#) and can be recharged over 6,000 times.

Mercedes-Benz is also working on a solid-state battery that will [increase range by 80%](#).

FEBRUARY 12, 2025

Engineers identify key obstacle to longer-lasting batteries

University of Texas at Dallas



Dr.

Kyeongjae Cho (left), professor of materials science and engineering, and doctoral student Matthew Bergschneider found that a chemical reaction involving oxygen atoms in lithium nickel oxide causes the material to become unstable and crack. Credit: University of Texas at Dallas

Lithium nickel oxide (LiNiO_2) has emerged as a potential new material to power next-generation, longer-lasting lithium-ion batteries. Commercialization of the material, however, has stalled because it degrades after repeated charging.

University of Texas at Dallas researchers have discovered why LiNiO_2 batteries break down, and they are testing a solution that could remove a key barrier to widespread use of the material. They [published](#) their findings in the journal *Advanced Energy Materials*.

The team plans first to manufacture LiNiO_2 batteries in the lab and ultimately to work with an industry partner to commercialize the technology.

"The degradation of batteries made using LiNiO_2 has been a problem for decades, but the cause was not well understood," said Dr. Kyeongjae Cho, professor of materials science and engineering in the Erik Jonsson School of Engineering and Computer Science and

director of the Batteries and Energy to Advance Commercialization and National Security (BEACONS) program.

"Now that we have a clear understanding of why this happens, we're working on a solution so the technology can be used to provide longer battery life in a range of products including phones and [electric vehicles](#)."

The research is a project of UTD's BEACONS initiative, which launched in 2023. The BEACONS mission is to develop and commercialize new battery technology and manufacturing processes; enhance the domestic availability of critical raw materials; and train high-quality workers for jobs in an expanding battery-energy storage workforce.

To determine why LiNiO_2 batteries break down during the last phase of charging, UT Dallas researchers analyzed the process using computational modeling. The study involved understanding chemical reactions and the redistribution of electrons through materials at the atomic level.

In [lithium-ion batteries](#), electrical current flows out of a conductor called the cathode, which is a positive electrode, into an anode, a negative electrode. The anode typically is made of carbon graphite, which holds lithium at a higher potential. During discharge, the lithium ions return to the cathode through the electrolyte and send electrons back to the lithium-containing cathode, as an electrochemical reaction that generates electricity.

Cathodes typically are made of a mixture of materials that includes cobalt, a scarce material that scientists aim to replace with alternatives, including lithium nickel oxide.

The UTD researchers found that a chemical reaction involving [oxygen atoms](#) in LiNiO_2 causes the material to become unstable and crack. To resolve the issue, they developed a theoretical solution that reinforces the material by adding a positively charged ion, or cation, to alter the material's properties, creating "pillars" to strengthen the cathode.

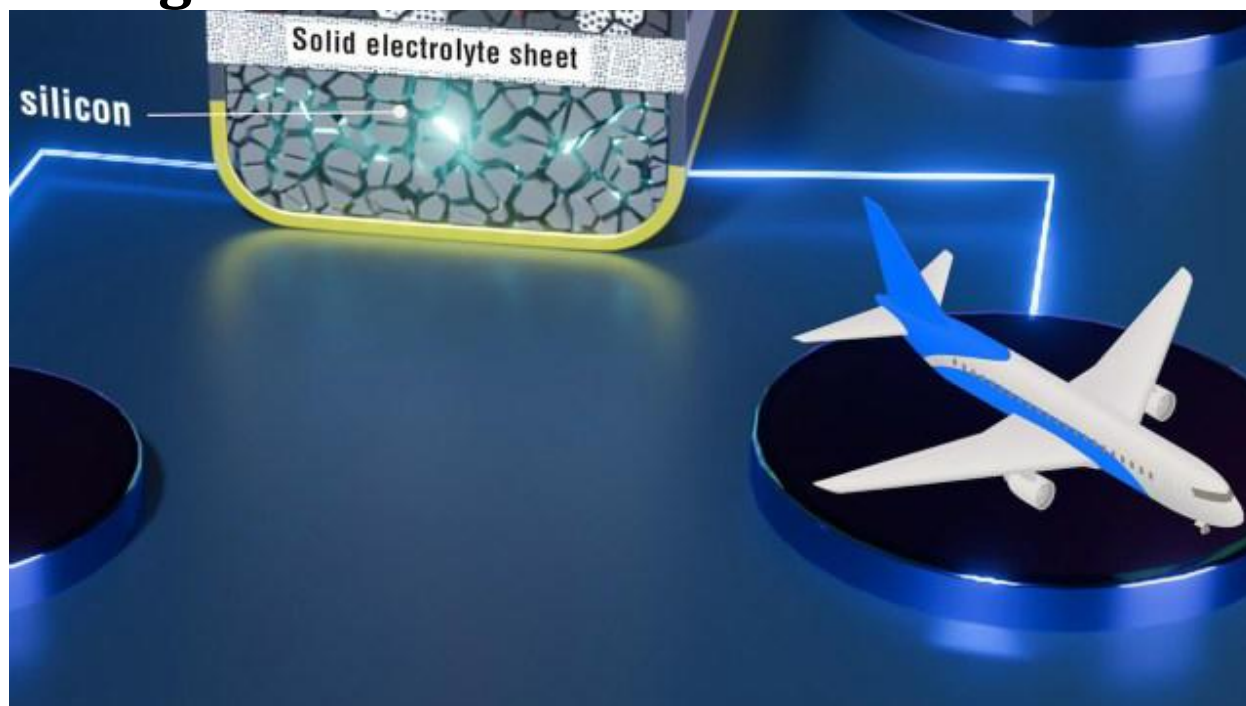
Matthew Bergschneider, a materials science and engineering doctoral student and first author of the study, has been setting up a robotics-based lab to manufacture battery prototypes to explore high-throughput synthesis processes of the designed pillared LiNiO_2 cathodes. The robotic features will assist with synthesizing, evaluating and characterizing the materials.

"We'll make a small amount at first and refine the process," said Bergschneider, a Eugene McDermott Graduate Fellow. "Then, we will scale up the material synthesis and manufacture hundreds of batteries per week at the BEACONS facility. These are all stepping stones to commercialization."

More information: Matthew Bergschneider et al, Mechanical Degradation by Anion Redox in LiNiO_2 Countered via Pillaring, *Advanced Energy Materials* (2024). DOI: [10.1002/aenm.202403837](https://doi.org/10.1002/aenm.202403837)

Journal information: [Advanced Energy Materials](#)
Provided by [University of Texas at Dallas](#)

Scientists develop breakthrough battery tech — here's how it could be 'vital' for next-gen EVs



It's part of the effort to deliver a cheaper, safer alternative to dominant lithium-ion packs.

A battery developed in Japan with two kinds of filling could transform how we power our [electric vehicles](#), laptops, and even futuristic human-like robots, [according](#) to Doshisha University researchers.

They are tackling electrolyte composition by including both solid and liquid versions in one pouch cell. When batteries operate, ions move between two electrodes through the electrolyte, which is crucial for the chemistry to work, [according](#) to the U.S. Department of Energy.

Most lithium-ion batteries, or LIBs, that power our EVs and other [tech](#) use a liquid electrolyte. It's reliable, but often contains flammable substances that can be a part of rare yet [serious](#) blazes. (Gas cars catch fire more often than battery-powered ones, [per](#) the Boston Globe.)

[Solid](#) electrolytes are safer, lighter, and have a faster charge time and a longer lifespan. But cost, and the lack of a scalable manufacturing process, have been

hurdles, [according](#) to TopSpeed. Doshisha's experts cited electrode-electrolyte ion transfer as another challenge. Ion movement is important during the charge/discharge cycle, [per](#) the researchers.

As a result, the team, including experts from Japanese electronics company TDK Corporation, sees a quasi-solid-state battery as a prime solution that maximizes the benefits of both types.

"The ... battery from our study has the potential to improve the longevity of liquid-based LIBs and enhance energy density while maintaining the safety of all-solid-state batteries," study lead Ryosuke Kido [said](#) in a news release.

[Energy density](#) is the amount of electricity that can be stored per pound, a clutch metric for performance described [here](#) by the DOE.

Doshisha's pouch cell includes a silicon negative electrode; a positive electrode made from lithium, nickel, cobalt, manganese, and oxygen; and a solid glass-ceramic electrolyte in the middle.

Specialized liquid substances that work well with each electrode were developed to enhance performance at the electrolyte interface. As a result, ionic conductivity, thermal stability, and electrochemical performance all tested "excellently," [according](#) to the summary.

"The flame-retardant quasi-solid-state battery we developed ... provides a safer and more durable alternative to all-solid-state batteries with high energy density," Kido said in the report.

Quasi-electrolyte research is happening elsewhere, too. Massachusetts' [Factorial](#) has one in development, with positive progress. At Doshisha, a [porous silicon anode](#) is another innovation testing well.

It's part of the effort to deliver a cheaper, safer alternative to dominant lithium-ion packs. While reliable, they contain hard-to-gather metals that are expensive and dependent on [foreign markets](#). That's in addition to increased fire risks with liquid-electrolyte versions.

But even EVs with the [dirtiest batteries](#) are cleaner than gas burners, [according](#) to the Massachusetts Institute of Technology. In fact, the DOE [reported](#) that EVs prevent thousands of pounds of [heat-trapping](#) air pollution each year compared

to internal combustion rides. That's true even in states where nonrenewables generate most of the electricity to charge them.

The gases released are linked to a long list of human health problems, many involving the lung and heart, [per](#) the World Health Organization. And while \$7,500 in EV tax breaks are in jeopardy under President Donald [Trump's](#) energy policies — as [reported](#) by NPR — the constant stream of innovations from Doshisha and other labs can help to lower costs. And the tax breaks remain [available](#) for now.

It all helps to make [switching](#) to a cleaner ride easier for more people. What's more, 2024 global EV and plug-in hybrid sales jumped 25% to more than 17 million, [according](#) to Reuters.

"As the world moves toward carbon neutrality, [electric vehicles](#) have been gaining significant attention in recent years. It is vital to develop highly safe automotive batteries with extended lifespans," Kido [said](#) in the summary.

Solid-State Batteries Are In 'Trailblazer' Mode. What's Holding Them Up?



Solid-state batteries could enable 600-mile EVs and reduce fires. Now, battery makers are racing to get them over the finish line.

For almost two decades, [solid-state batteries](#) have been hailed as *the* game-changer for electric vehicles. A breakthrough that promises to eliminate range anxiety, slash charging times and make electric cars as practical and convenient as gas-powered ones—without the nasty tailpipe emissions that pollute the air and harm human health.

And yet, solid-state batteries have felt like they've been trapped in the lab. So what's holding them back? How close are they to powering EVs? Are they even real, or will this technology always be science fiction?

Experts told [InsideEVs](#) that solid-state battery progress isn't as sluggish as it seems. Companies are closer than ever to commercialization, but hurdles remain. Just like lithium-ion batteries, their build-out is expected to be slow and gradual. Semi-solid-state batteries are set to hit the market first, serving as a "bridge technology" before fully solid-state packs reach mass production.

"We're in the mode of trailblazing the breakthroughs to move them closer to automotive applications," Siyu Huang, the CEO of battery startup Factorial told InsideEVs. "The main challenge for solid-state is scalability," she added—the ability to produce them in mass quantities.

How This Works

In a traditional lithium-ion cell, the electrolyte—the material that carries the charge-carrying ions between the charging and discharging cycles—is typically a lithium-based liquid chemical. Solid-state batteries swap that out for a solid electrolyte, often made of polymer, sulfides or oxides. The goal remains the same: shuttling electrons between the cathode and anode to power the vehicle.

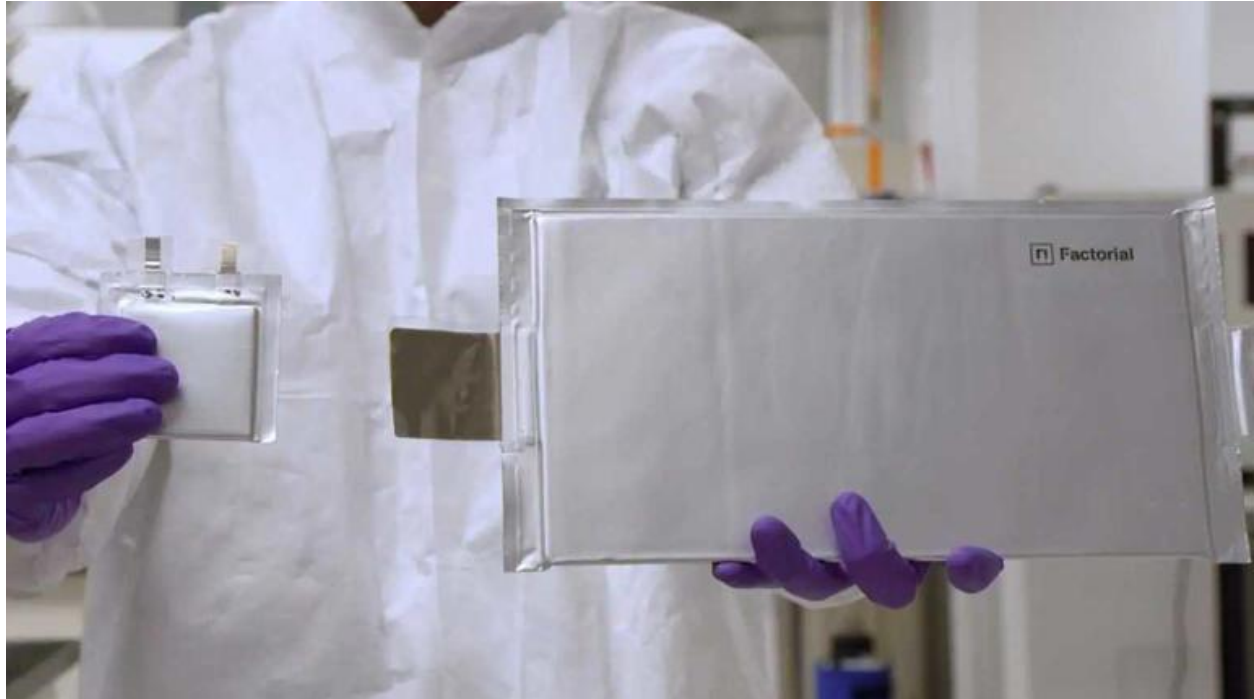
[Research](#) has shown that this switch brings key advantages. Solid-state batteries pack more energy into a smaller space; they're faster charging while also being safer and delivering better thermal stability than traditional lithium-ion

batteries. In theory, this should eliminate many common and troubling problems with EVs: range losses in extreme temperatures, fire risks and more.

Semi-solid state batteries, on the other hand, use a gel-like electrolyte instead of a fully liquid or solid one, offering better energy density and safety. They're a hybrid solution between conventional lithium-ion and all solid-state batteries.

Now, there's a massive push to bring both these battery chemistries to life. Huang's Massachusetts-based [Factorial](#) is among the leaders in this space. It has entered into joint development agreements with Mercedes-Benz, Stellantis and the Hyundai Motor Group (which [may even reveal its own solid-state prototypes next month](#), according to reports.)

Several other players are also racing to develop this tech. California-based [QuantumScape](#) has an agreement with Volkswagen Group's battery subsidiary PowerCo to industrialize solid-state batteries. The BMW Group and Ford have invested millions of dollars in Colorado-based [Solid Power](#). And [Toyota](#) and [Honda](#) are leading their own in-house solid-state battery development efforts in Japan.



Last year, Factorial revealed its Solstice all-solid-state battery. It uses a sulfide-based electrolyte claimed to achieve a breakthrough energy density of 450 watt-hours per kilogram. Most lithium-ion cells currently used in EVs have an energy density of well under 300 Wh/kg. A higher energy density means an EV battery can store more power without getting bigger or heavier, leading to longer driving range.

Why Is It So Hard?

The U.S. government's [National Science Foundation](#) explains in great detail the manufacturing requirements for solid-state batteries and how different they are from lithium-ion batteries. Simply put, battery manufacturing requires three main processes: electrode production, cell production, and cell conditioning.

These processes and the related supply chain is heavily optimized for the production of lithium-ion batteries. Now the challenge lies in reconfiguring those for solid-state batteries. That shift is akin to the transition from ink to laser printing, or replacing copper wires to fiber optic cables. It needs a redesign and rethink of the entire infrastructure. And since the technology is still new, researchers are working to overcome these hurdles to achieve consistent performance and reliability.

"All of these processes will be altered for solid-state batteries and are highly dependent on the material properties of the solid electrolyte," the paper says, before concluding that the near-term solution to fast-track commercialization would likely "be a hybrid approach which adopts processes from both conventional LIBs and solid oxide fuel cell communities."

Factorial is doing just that, incorporating its proprietary processes while carrying over some of the proven techniques used to make lithium-ion batteries.

Last year, it opened what's claimed to be the [largest solid-state battery manufacturing line](#) in the U.S. in Methuen, Massachusetts. The 200 megawatt-hour line seems small compared to the giant battery plants being erected across the U.S. with hundreds of gigawatt-hours of capacity. But Factorial's line is still a big milestone.

It has already sent a “B-sample” to Mercedes-Benz for testing, claiming to be the first battery company to send a sample of an all-solid-state battery to a global automaker. B-sample refers to a near-production prototype of a battery. It's used for more advanced testing, such as performance validation, safety assessments and integration into EVs.



Mercedes-Benz Vision EQXX Concept exterior© InsideEVs

Building these cells without defects on an assembly line is also a challenge. “We’re able to get an 85% yield for the pilot line,” Huang said, referring to the rate of cells produced that meet quality standards and are considered usable. “Usually, in a big manufacturing line, you need to have more than 95% yield,” she said. So, there’s still some refinement and scalability left to achieve.

The 40Ah Solstice cells also use a novel production process called dry cathode coating—a process [Tesla has also been reported to have been exploring for its next-generation cells](#).

According to the [Oak Ridge National Laboratory](#), the electrodes in traditional lithium-ion batteries use a wet slurry that's expensive, harmful to the environment and takes up a lot of space on the factory floor. The dry process eliminates this toxic slurry by mixing “dry powders with a binder,” which can cut

costs, slash energy use, and shrink the environmental footprint of battery production.

Over 600 Miles Of Range?

The result? Factorial claims its energy-dense packs can deliver a driving range of over 600 miles. That's more than double the average EPA-rated driving range in the U.S., which according to the Department of Energy was [283 miles](#). That in itself is a feat because it has tripled over the last decade. Factorial also claims operating temperatures of over 90 degrees Celsius and a 40% weight reduction over traditional batteries.

However, Factorial's quasi-solid-state battery is a near-term solution that can also deliver a high performance and also easily scale up. It uses a gel-like material for the electrolyte along with a lithium metal anode and a high-capacity cathode. This combines the advantages of solid-state electrolytes with the manufacturability of conventional lithium-ion batteries, the company claims.

Semi-solid state batteries have already entered the Chinese market. Last year, a [Nio ET7 owner achieved 554 miles](#) (892 km) of range on a single charge, thanks to its 150-kilowatt-hour semi-solid state pack.

They're soon coming to the U.S., too. Stellantis has promised to launch a [demonstration fleet](#) of the Dodge Charger Daytona equipped with Factorial's quasi-solid-state batteries next year. It is claimed to have an energy density of 390 Wh/kg, much higher than the current industry standards of around 250-300 Wh/kg.



2025 Dodge Charger Daytona EV

Photo by: InsideEVs

They also bring huge weight advantages. Huang added that solid-state batteries can save up to 200-300 pounds on the pack level. "On the vehicle level, SSBs can even save up to 1,000 pounds," she said. "If we reduce the pack weight, we can also reduce the supporting structures." Weight saving is directly tied to cost saving. With every pound eliminated, battery makers can save \$5, Huang said. If they can slice 1,000 pounds, that's a big cost differentiator.

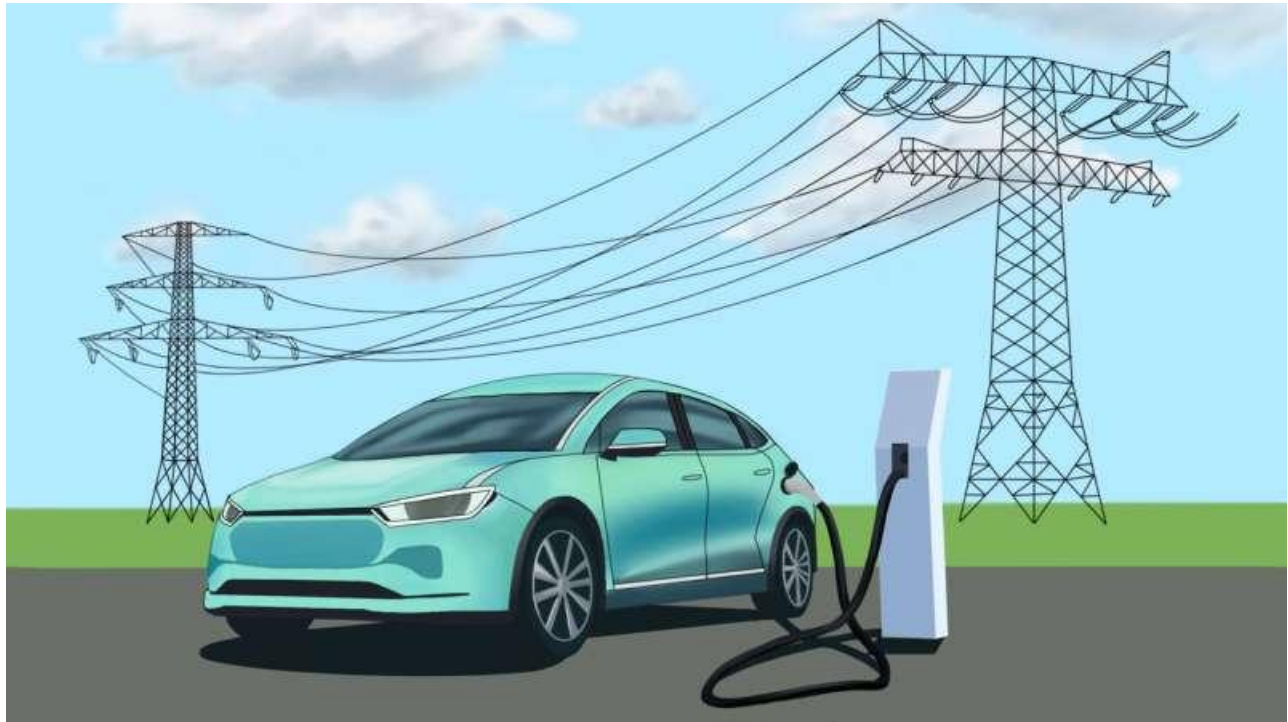
"The U.S. loves really big, non-aerodynamic SUVs and trucks," Recurrent's Najman said. "These require huge batteries to compensate for their poor physics, and they get really heavy. SSBs can offer more power in a much lighter package, so they may find use in the SUV/truck segment," she added. However, automakers are moving towards [extended-range powertrains for larger vehicles](#), which have backup gas generators to charge the battery.

All said solid-state batteries are primed to live up to the hype, Najman added. "The hype is part of what has made manufacturers extra cautious," she said. "With all the promise of SSBs, you don't want to release one that flops."

FEBRUARY 20, 2025

What can electrifying your ride do to the grid?

by Katie Satterlee, [Texas A&M University College of Engineering](#)



Credit: Kaitlyn Johnson/Texas A&M Engineering

Around 1 in 5 cars sold last year were electric vehicles (EVs). While they offer benefits—including zero tailpipe emissions, minimizing noise pollution, and reducing reliance on imported fossil fuels—they could also include drawbacks. EVs may strain the power grid.

In the Department of Electrical and Computer Engineering at Texas A&M University, Dr. Thomas Overbye, a professor and the Texas A&M Engineering Experiment Station Smart Grid Center director, and Dr. Jonathan Snodgrass, a senior research engineer, are working to understand the ramifications of the increased number of EVs on the power grid—and how to potentially use EVs to the grid's advantage.

"If everyone got an electric vehicle, it would more or less double the usage of the grid, and that's a big deal," Snodgrass said. "So, the question is, how do we leverage the flexibility of residential charging? Because if EVs are flexible, they can actually be an asset to the grid, not just a liability."

Flexible charging is used to maintain balance, Snodgrass added. For instance, right now, when a user plugs their car in for the night, the car starts charging immediately, which adds strain on the grid, since the grid usually has its highest load between 4–7 p.m. However, if

we can use the "smarts" in an EV charger to allow the utility company to change when the vehicle charges, the EV can truly become a flexible load.

Known as a price-responsive load, the EV could charge for the first three hours, then stop and start again, depending on what the grid can handle. All of this would consider a user's driving needs and ensure their car is charged before they leave the next morning.

"Suppose you get home at eight or nine at night after running your errands and picking up your kids," he said. "When you plug in your car, you don't necessarily care when it charges, you just care if it's going to have enough juice to get you to work and school in the morning."

Charging Levels

Typically, charging EV batteries can range from hours to days, depending on the charging speed. Level 1 uses a standard 120-volt house outlet and can take days to fully charge a car or truck. Level 2 uses a 240-volt supply, the kind that water heaters need, and can charge most electric vehicles overnight.

If a user wants to quickly charge their EV, they use Level 3 fast chargers, which are high-speed charging stations. A fast charger at 50 to 350 kilowatts has the same [electricity demand](#) as 25 to 50 houses and can charge a car in 30 to 60 minutes. Since these stations have their own converters, the car does not have to rely on its slower internal converter. However, it's a big load on the grid.

Imagine several people pull up at the same time to a [charging station](#) and plug in their EVs to DC fast chargers. A megawatt of load would be added to the power grid almost immediately, and the frequency of the grid would fluctuate because the balance between electricity supply and demand is off. The grid prefers a load that changes predictably and smoothly.

"The power grid can handle multiple megawatt loads, switching in and out, but it puts pressure on the grid," Snodgrass said. "It's not designed for that. It's like, can you drop a glass on the floor without it breaking? Yeah, totally. But it's not designed to be dropped on the floor. It was designed to be placed down carefully and lifted up carefully."

Partnerships

The research team is working with the Texas A&M Transportation Institute (TTI) and ElectroTempo, a leading software firm and a startup out of TTI.

"TTI is one of the best transportation centers in the world, and we have one of the best grid modeling groups in the country led by Professor Overbye, the group leader for energy and power in the electrical and [computer engineering](#) department. For a university, we have some of the best grid modeling and simulation capabilities in the world," Snodgrass added.

ElectroTempo takes real transportation data (i.e., real miles traveled) and converts it to EV miles to determine a forecasted load. They pass the data to Overbye's team, and they

perform grid simulations to make predictions about the impact it would have on the grid if "x" percent of people switched to EVs.

With that information, they could inform utility companies if distribution, transmission lines or transformers need to be upgraded or if they could expect overload problems in certain areas. Some of those issues could be solved by shifting the EV load around or by replacing power lines or transformers before they become overloaded.

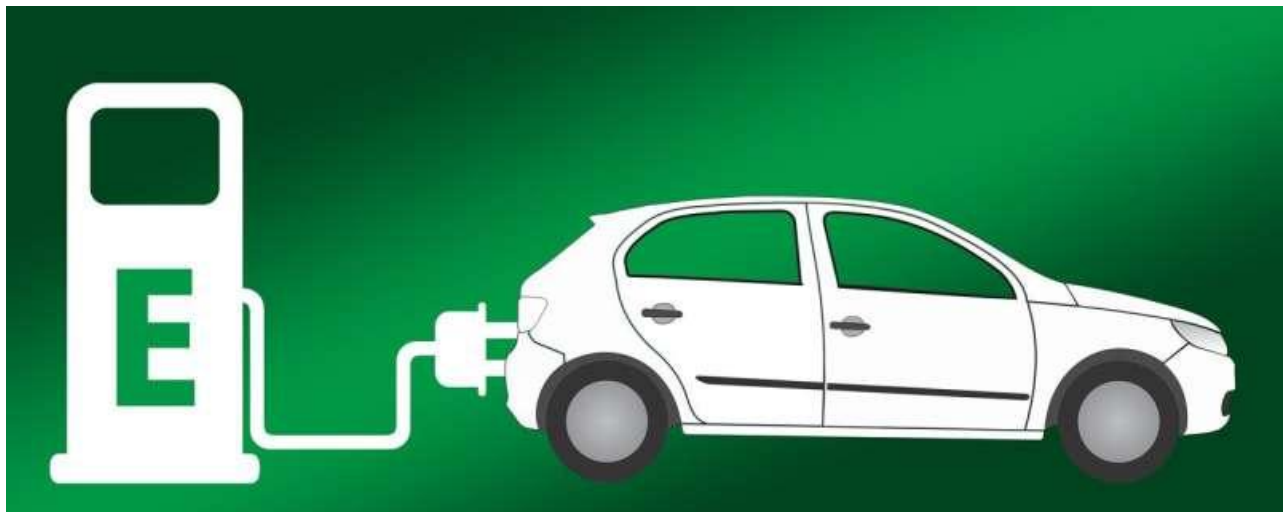
"In some cases, it may not be worth electrifying a certain area. For example, utilities should tell people who live in this neighborhood, if you really want [electric vehicles](#), the first 10% of customers can electrify, no problem. After that, they will have to pay a surcharge because utilities will need to upgrade your line. It depends on how utility companies want to handle it," Snodgrass said.

Provided by [Texas A&M University College of Engineering](#)

FEBRUARY 20, 2025

Switching to electric vehicles will push the power grid to the brink

by Florimond Gueniat, [The Conversation](#)



Credit: Pixabay/CC0 Public Domain

The UK's pledge to reach [net-zero emissions by 2050](#) hinges on replacing millions of petrol and diesel vehicles with cleaner alternatives. But transitioning to electric transport isn't just about manufacturing new cars, installing chargers and so on. It's a gargantuan energy generation challenge that could push the power grid to its limits.

In 2023, UK transport consumed about [46 million liters of petrol and diesel](#). If we convert that into electricity, it would be equivalent to 49.5 gigawatts (GW) of continuous power throughout a whole year. For perspective, this is about one-third more than the UK's entire current electricity generation capacity.

In other words, every single power station in the UK could be devoted entirely to powering electric vehicles and it still wouldn't be enough. But one might say we didn't consider the efficiency of [electric vehicles](#). Petrol and diesel engines waste about three quarters of their energy as heat, with only a small portion used to propel the car. Electric vehicles meanwhile [waste only about one quarter](#).

Adjusting for this, the actual power needed if the UK went entirely electric drops to around 20 GW. It would still mean increasing today's grid capacity by almost half (46%), corresponding to building 17 [nuclear plants](#) (1.2 GW each) or 5,800 skyscraper-sized wind turbines (3.5 MW each). Those [wind farms](#) would cost around £22 billion, while the nuclear plants would cost significantly more.

At the moment, less than 1% of vehicles in the UK are electric, which explains why there are no specific power issues—yet. But if the country did have a fully carbon-free fleet of vehicles, the associated surge in demand would strain infrastructure and risk large blackouts. California's grid, for example, already faces [stress during electric vehicle charging peaks](#), prompting warnings and forcing the state to put "managed charging" policies in place.

Massive upgrade needed

Most countries looking to switch to zero-carbon transport will need to massively upgrade their electricity grid and power plants. Renewable energy complicates matters as wind and solar can't always meet demand spikes (you can burn more gas or coal when needed, but you can't choose when the wind blows or the sun shines). Nuclear offers stable and massive output, but new plants can take decades to build and the public is often hostile.

Certain "smart" solutions could help things even if the grid itself isn't overhauled. Electric vehicle batteries could be linked to the grid for instance, and used to store and supply power. Overnight, millions of cars will soak up electricity before releasing it when demand spikes again in the morning. Price discounts would encourage people to charge their cars at night, when demand for electricity is at its lowest.

This can help mitigate many of the issues related to wind and solar being intermittent. But it will cause batteries to deteriorate faster, and still won't solve the problem of having to generate more electricity.

One underappreciated strategy is empowering households and businesses that generate their own electricity via [solar panels](#), small wind turbines, or even micro-hydro systems. By 2035, with vigorous policies, these "prosumers" could supply up to 15% of the UK's electricity, easing grid strain and reducing reliance on centralized funding. [Such policies in Germany](#) have led its prosumer networks to already offset 10% of the national demand.

Without such decentralized efforts, the financial burden of grid upgrades will fall entirely on taxpayers, at staggering costs. The alternative is a huge rise in price of electricity, felt by all, and a stalled transition.

No time to delay

Generating more power remains the core issue. Without urgent action, the transition to low-carbon transport could stall—or worse, overload the energy system. The governments of [France](#), the [UK](#) and some other countries have recently begun to discuss increasing energy production, but the focus is on meeting AI-related demands rather than electricity for the next generation of vehicles.

Critically, net-zero will only happen with strong transport and energy policies in place. Governments must increase grid capacity and incentivize small-scale renewable generation through tax breaks and specially-designed payments. The alternative—delaying and relying solely on public funds—is economically unviable and politically risky.

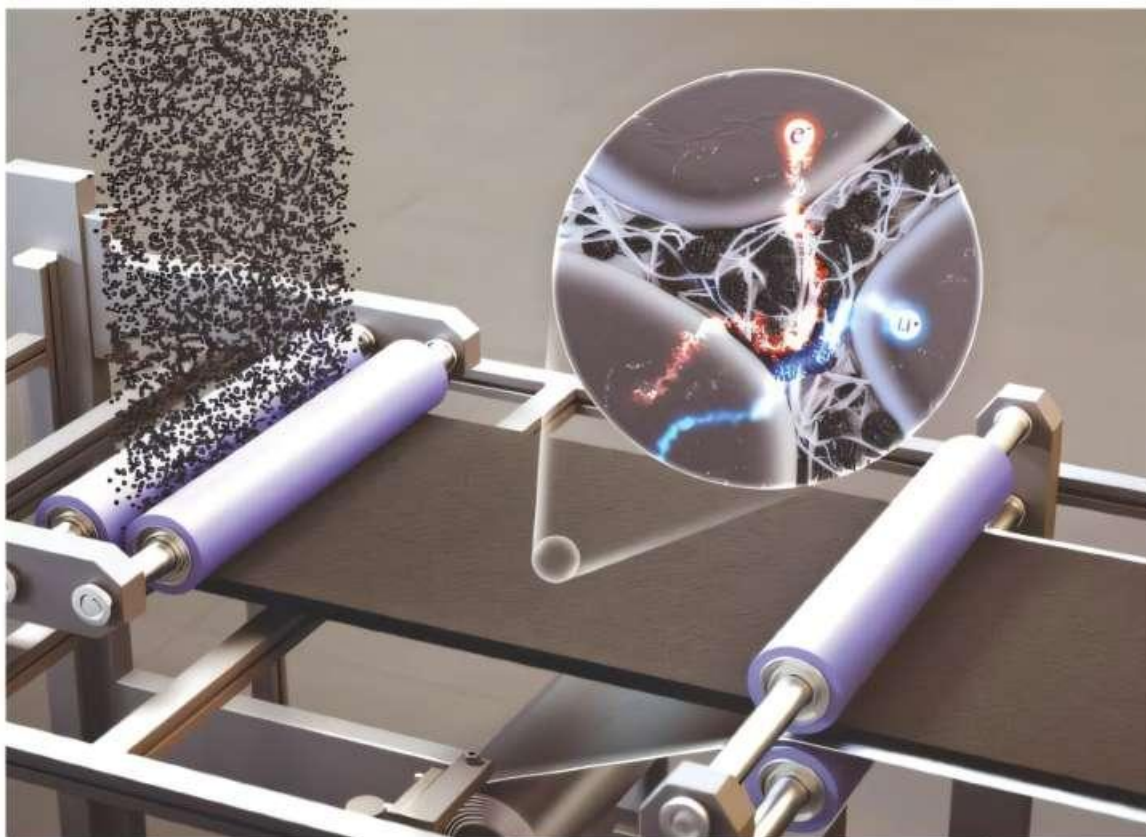
Provided by [The Conversation](#)

This article is republished from [The Conversation](#) under a Creative Com

FEBRUARY 24, 2025

Enhanced battery electrode could enable more than 600 km of travel on single charge

by [Ulsan National Institute of Science and Technology](#)



Dry-processed thick electrode design with a porous conductive agent enabling 20 mA h cm^{-2} for high-energy-density lithium-ion batteries. Credit: *Energy & Environmental Science* (2024). DOI: 10.1039/D4EE04106B

A research team led by Professor Kyeong-Min Jeong in the School of Energy and Chemical Engineering at UNIST, has unveiled an electrode that is five times thicker than existing models, utilizing the dry process.

This advancement not only enhances [battery capacity](#) but also maintains rapid charging speeds, aligning with environmental goals by eliminating the use of chemical solvents. The work is [published](#) in the journal *Energy & Environmental Science*.

As the demand for high-capacity lithium-ion batteries surges with the rise of electric vehicles (EVs), there is a growing focus on design strategies that maximize electrode thickness while

minimizing inactive components. Unfortunately, traditional wet electrode manufacturing methods have struggled to create thicker electrodes, often resulting in clumping during the solvent evaporation stage due to the nature of powder-type electrodes.

In contrast, Professor Jeong's research team successfully engineered an electrode up to five times thicker, achieving a mixture layer density of 3.65 g/cm^3 , which is directly related to its capacity. The resultant areal capacity of the electrode is an impressive 20 mAh/cm^2 , significantly exceeding that of commercial counterparts.

When integrated into batteries, this innovative electrode could enhance the driving range of electric vehicles by approximately 14%. "While conventional electric vehicle batteries have made the journey between Seoul and Busan challenging, our technology has the potential to enable over 600 kilometers of travel on a single charge," stated Professor Jeong.

Additionally, the new electrode design incorporates a porous spherical conductive material that significantly boosts conductivity. In typical scenarios, increased [electrode](#) thickness results in longer lithium-ion transport distances, thereby reducing output and slowing charging speeds. However, the use of specialized materials like the porous spherical conductive agent can mitigate these challenges, a feat not feasible with traditional wet methods.

"This technology marks a significant breakthrough, advancing both capacity and performance of eco-friendly dry electrodes," remarked Hyesong Oh, the first author of the study. "It is particularly noteworthy for demonstrating the performance of 1 Ah-class pouch cells, paving the way for large-scale production beyond laboratory coin cell experiments."

More information: Hyeseong Oh et al, Dry-processed thick electrode design with a porous conductive agent enabling 20 mA h cm^{-2} for high-energy-density lithium-ion batteries, *Energy & Environmental Science* (2024). DOI: [10.1039/D4EE04106B](https://doi.org/10.1039/D4EE04106B)

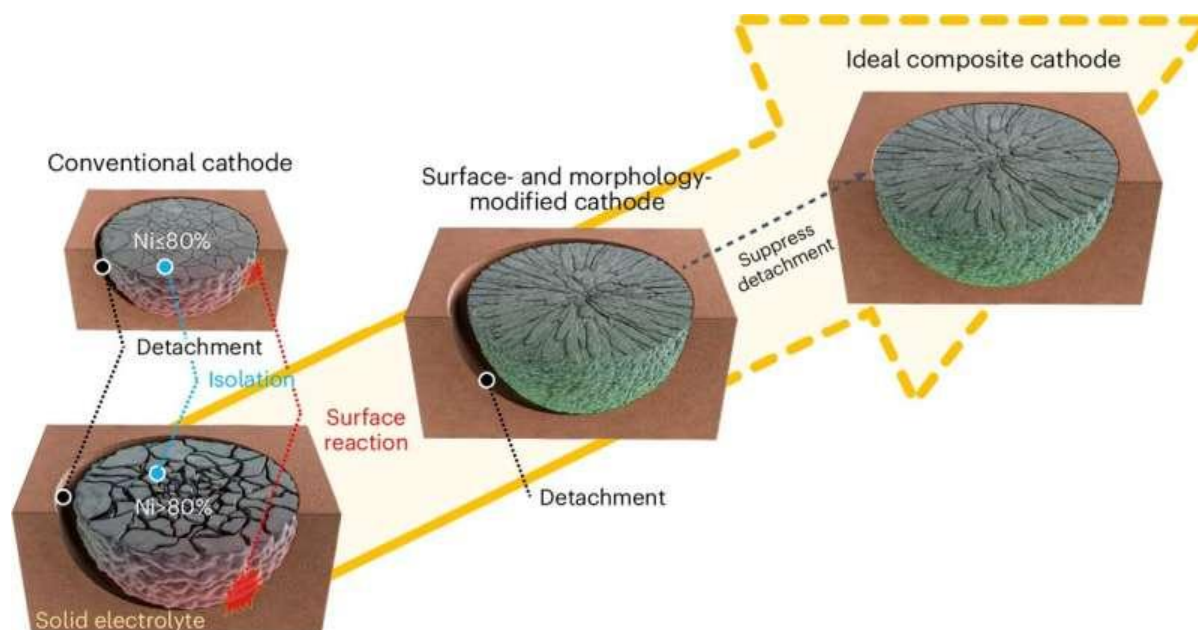
Journal information: [Energy & Environmental Science](#)

Provided by [Ulsan National Institute of Science and Technology](#)

MARCH 5, 2025

New highly performing Ni-rich cathode active materials for all-solid-state batteries

by Ingrid Fadelli , Tech Xplore



Schematic illustration of strategies to overcome each factor of capacity fading in ASSBs. Credit: *Nature Energy* (2025). DOI: 10.1038/s41560-025-01726-8

To support the further advancement of the electronics industry, energy researchers have been trying to develop new battery technologies that could be charged faster, power devices for a greater amount of time and have longer overall lifetimes. Some of the most promising emerging batteries that could meet these requirements are all-solid-state batteries (ASSBs).

ASSBs are batteries that contain [solid electrolytes](#), as opposed to the liquid electrolytes found in conventional battery technologies. Compared to [lithium-ion](#) (Li-ion) batteries, which are currently the most widely used [rechargeable batteries](#), ASSBs could be safer, as solid electrolytes are typically less likely to catch fire, and could also store more energy (i.e., have higher energy densities).

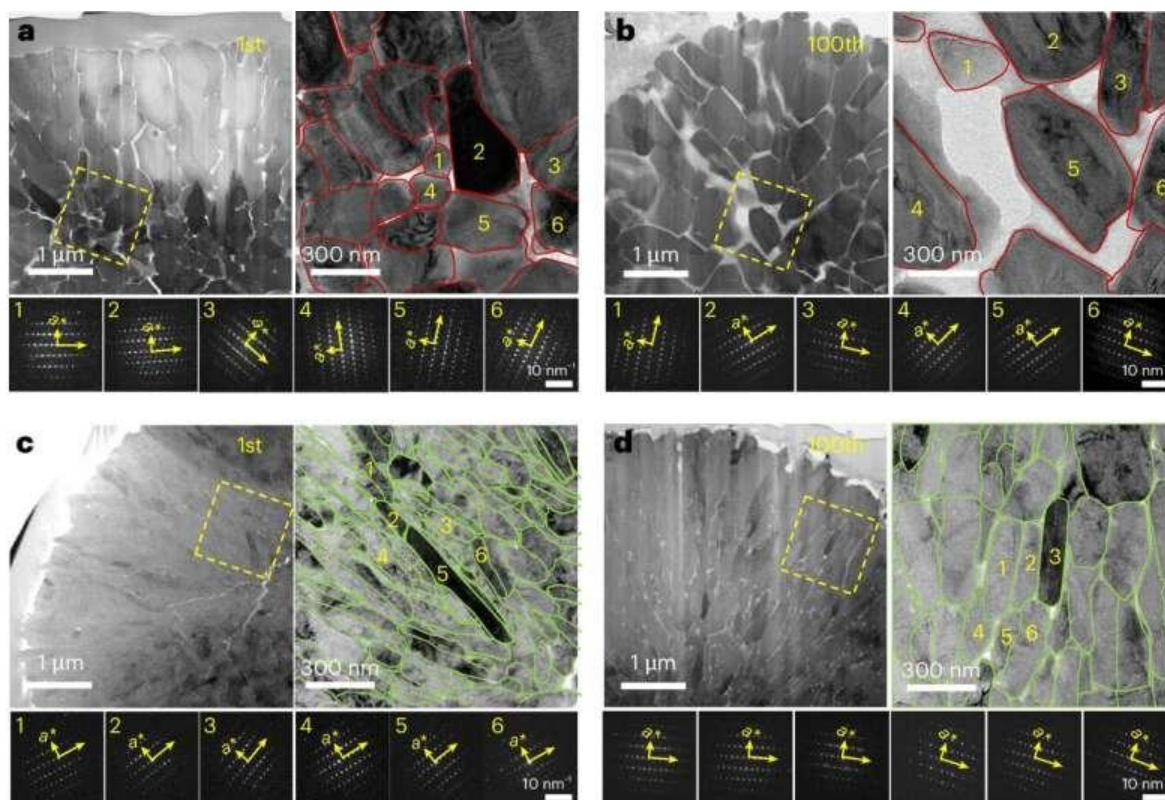
A central component of these batteries is the so-called [cathode active material](#) (CAM), a component that stores and releases lithium ions. Layered materials rich in nickel (Ni) have been particularly promising CAMs, yet they were also found to exhibit significant limitations.

Specifically, past studies showed that these cathodes can reduce the ability of ASSBs to hold charge over time, a process known as capacity fading. The reduction in capacity they prompt was linked to chemical reactions at the interface between Ni-rich cathodes and electrolytes, as well as the expansion, contraction and disintegration of cathode particles.

Researchers at Hanyang University in South Korea recently carried out a study to better understand how the amount of Ni in CAMs influences the degradation of ASSBs. Their findings, [published](#) in *Nature Energy*, informed the development of new Ni-rich cathodes that could boost the performance and lifetime of ASSBs.

"ASSBs comprising Ni-rich layered cathode active materials (CAMs) and sulfide solid electrolytes are promising candidates for next-generation batteries with high energy densities and safety," wrote Nam-Yung Park, Han-Uk Lee and their colleagues in their

paper. "However, severe capacity fading occurs due to surface degradation at the CAM–electrolyte interface and severe lattice volume changes in the CAM, resulting in inner-particle isolation and detachment of the CAM from the electrolyte."



Crack formation behavior in S-Ni90 and SM-Ni90 CAMs at the charged state. Credit: *Nature Energy* (2025). DOI: 10.1038/s41560-025-01726-8

As part of their study, Park, Lee and his colleagues first set out to identify each factor influencing the degradation of ASSBs with Ni-rich CAMs and quantify their effects. To do this, they synthesized four different types of Ni-rich cathodes, with Ni content ranging from 80 to 95%.

These included pristine $\text{Li}[\text{Ni}_x\text{Co}_y\text{Al}_{1-x-y}]\text{O}_2$ cathode materials, boron-coated CAMs, Nb-doped CAMs and CAMs that were both boron-coated and Nb-doped CAMs. They then closely examined how these different cathode materials and their Ni concentrations influenced the degradation of ASSBs.

"We quantified the capacity fading factors of Ni-rich $\text{Li}[\text{Ni}_x\text{Co}_y\text{Al}_{1-x-y}]\text{O}_2$ composite ASSB cathodes as functions of Ni content," wrote Park, Lee and their colleagues. "Surface degradation at the CAM–electrolyte interface was found to be the main cause of capacity fading in a CAM with 80% Ni content, whereas inner-particle isolation and detachment of the CAM from the electrolyte play a substantial role as the Ni content increases to 85% or more."

Overall, the researchers found that surface degradation at the interface between the Ni-rich cathode materials and [electrolyte](#) was the primary cause for the degradation of ASSB capacity. The isolation of inner-particles and their detachment from the cathode materials,

on the other hand, was found to only affect the capacity of batteries when the cathodes contained over 85% of Ni.

Park, Lee and his colleagues subsequently drew from their findings to develop new Ni-rich CAMs with an altered surface and morphology. These materials have columnar structures that were found to effectively reduce the detachment of particles from the cathode materials and inner-particle isolation.

When deployed in a pouch-type full cell with a C/Ag anode-less electrode, these new cathodes retained 80.2% of their initial [capacity](#) after 300 operation cycles. The valuable insight gathered by this research team and the cathodes they developed could soon help to improve the performance of ASSBs further, potentially contributing to their future deployment and widespread adoption.

More information: Nam-Yung Park et al, High-energy, long-life Ni-rich cathode materials with columnar structures for all-solid-state batteries, *Nature Energy* (2025). DOI: [10.1038/s41560-025-01726-8](https://doi.org/10.1038/s41560-025-01726-8).

Journal information: [Nature Energy](#)

© 2025 Science X Network

MARCH 5, 2025

Electric vehicles could travel farther on a single charge thanks to lithium-sulfur batteries with added platinum

by Angela Nicoletti, [Florida International University](#)



Close-up of one of the battery cells created in El-Zahab's lab. Credit: Margi Rentis/FIU
More electric vehicles are on the road than ever before. But a recent global survey has found that some EV owners—about 46% in the U.S.—have considered switching back to a gasoline car. The top reason: charging. While average ranges have steadily increased over time, drivers' expectations still outpace what current lithium-ion batteries can deliver.

Now, Florida International University researchers have made a breakthrough with a next-generation [battery](#) technology, known as "beyond [lithium-ion](#)," that could one day make owning an EV a lot more convenient.

"We started working with these next-generation battery chemistries eight years ago. The first charging cycle was great. By cycle 20, it was a useless lump of metal," said Bilal El-Zahab, an associate professor in the College of Engineering & Computing. "We had to become battery whisperers to solve the problems with them, so it's really exciting to be at this stage."

El-Zahab and his group at the FIU Battery Research Lab focused on lithium-sulfur, a beyond lithium-ion technology and one of the most promising alternatives to lithium-ion.

It's both lightweight, less expensive and incredibly energy-dense (meaning more charge can be carried). That allows EVs to go farther and laptops, smartphones and other devices to run for twice as long.

The downside: The lithium-sulfur chemistry that makes the battery last so long ultimately undermines the battery's longevity, rendering it useless after 50 or so complete charges.

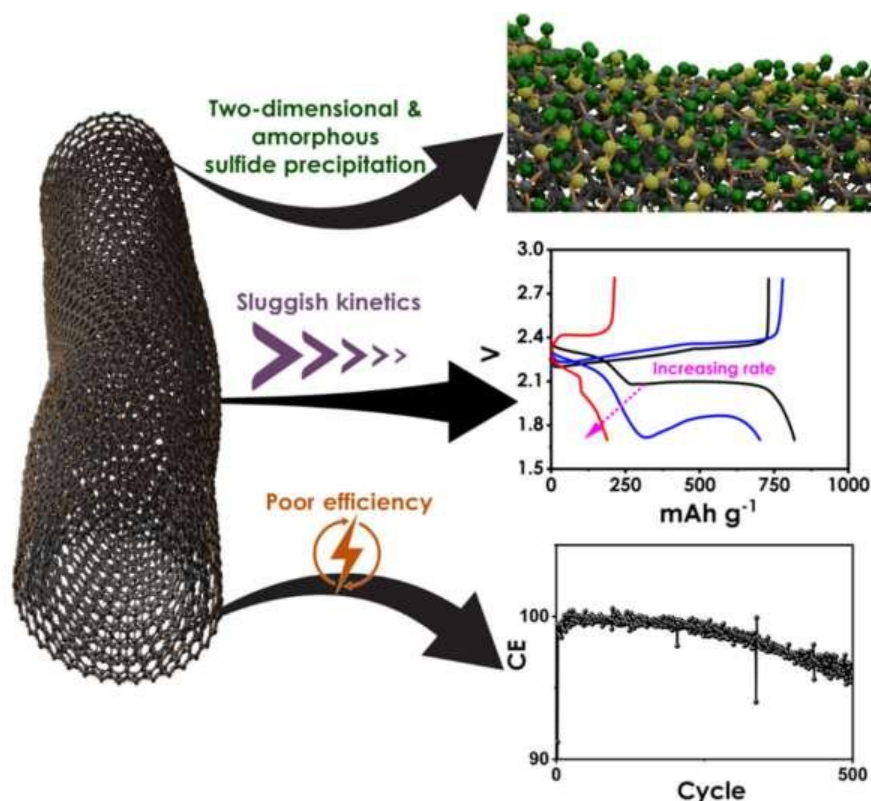
After years of testing, El-Zahab's team discovered a solution to lengthen the lifespan of lithium-sulfur. All it took was introducing a little metal into the mix. Platinum stabilizes battery performance and boosts storage capacity closer to commercial viability. The results of their research were recently [published](#) in Energy & Environmental Materials.

"We achieved a 92% retention after 500 charging cycles, which means the battery is nearly as good as new," said Aqsa Nazir, an FIU postdoctoral researcher in El-Zahab's lab and first author of the study. "It also shows we minimized the negative reactions that hurt overall performance to bring this battery to the commercial level."

All batteries function in a fairly straightforward manner: Ions move from one side of the battery to the other, back and forth, depending on whether it's charging or releasing energy. However, this process is a bit messier with lithium-sulfur. One side of the battery is made of lithium, the other is made of sulfur.

When ions of lithium carrying charge reach the sulfur side, a chemical reaction occurs between the lithium and sulfur, resulting in the formation of lithium-containing sulfur compounds, called polysulfides, that are then carried to the lithium side during charging.

Over time, this causes a mossy build-up on the lithium side, which reduces [energy efficiency](#) and leads to the battery's eventual deterioration.



Schematic illustration of the major issues facing LSBs with carbon-based cathodes that include two-dimensional and amorphous sulfide precipitation, sluggish kinetics, and poor coulombic efficiency (CE). Credit: ENERGY & ENVIRONMENTAL MATERIALS (2024). DOI: 10.1002/eem2.12844

To counteract this damaging chemical reaction, researchers added tiny nanoparticles of platinum to the sulfur side of the battery. Just as safety officers direct traffic to prevent accidents or backups, platinum works at the molecular level to guide the lithium, ensuring it keeps flowing smoothly.

Only a miniscule amount—about 0.02% of the total battery—was needed to make a difference.

"Adding nanoparticles of platinum to the battery is like adding a pinch of salt to food: A small amount can have an outsized impact," said El-Zahab.

El-Zahab's lithium-sulfur battery is currently undergoing third-party testing—a critical step before it leaves the lab for licensing and commercialization.

More information: Aqsa Nazir et al, Targeted Electrocatalysis for High-Performance Lithium–Sulfur Batteries, Energy & Environmental Materials (2024). DOI: [10.1002/eem2.12844](https://doi.org/10.1002/eem2.12844)

Provided by [Florida International University](https://www.floridainternationaluniversity.edu/)