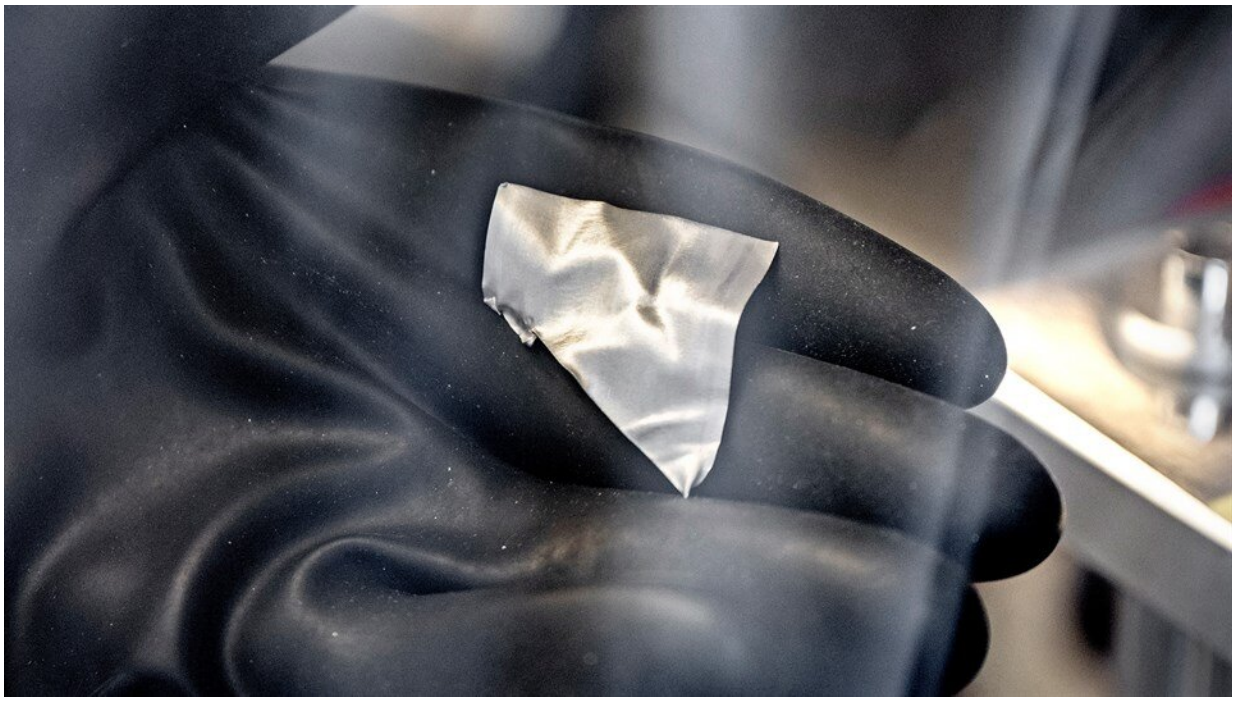
Recycling and rethinking batteries

October 3 2022, by Miriam Meister



In the laboratory, lithium is kept in a glove box because it reacts with the oxygen, water and CO2 in the air around us. The box contains pure argon gas. The oxygen and water content in the box is 0.1 parts per million. Credit: Bax Lindhardt

The rapid increase in electric car sales is causing a battery shortage. To solve this problem, we must get better at recycling the raw materials used in batteries and accelerate the development of new battery types.

It seems like a natural consequence of his conviction when Professor Poul Norby drives his electric car almost silently into the parking lot at DTU Lyngby Campus on his way to the office. Here, his research focuses on creating knowledge that can pave the way for better batteries in cars, among other things.

"In my view, the electric car solves far more problems than it creates," says the professor.

The green status of electric cars has always been heavily debated, particularly because the production of electric car batteries generates significantly more CO_2 than conventional car batteries, and the extraction of their raw materials is potentially problematic.

However, life cycle analyses of an electric car's life—from assembly line to scrapyard—shows that electric cars in Denmark emit significantly less CO_2 overall than cars running on petrol or diesel. In addition, measures have been put in place to ensure an eco-friendlier extraction that will benefit the miners as well as the environment.

Poul Norby is just one among a growing group of people investing in a fossil-free future by buying an electric car: According to figures from the International Energy Agency, 6.6 million electric cars were sold worldwide last year. That is three times as many as two years earlier. In fact, the average number of electric cars sold in just one week in 2021 was equal to the total number of electric cars sold during the whole of 2013.

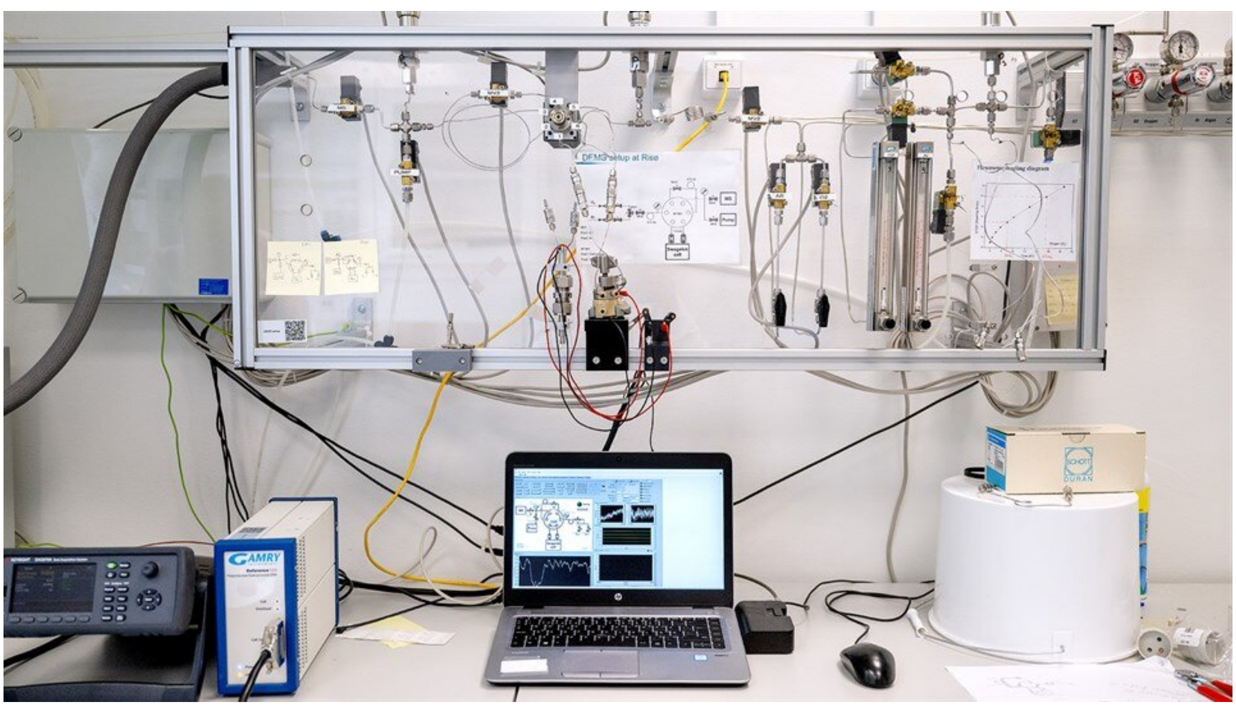
This rapid increase in sales is leading to a battery shortage. Partly because it will be difficult to extract raw materials such as cobalt, lithium, nickel, and graphite, which are currently often used in batteries, quickly enough and responsibly. And partly because the demand for batteries is likely to exceed production capacity for a period of time.

Pressure on raw materials

In a study from April this year, researchers from KU Leuven in Belgium estimated that to achieve the goal of becoming climate neutral by 2050, Europe will need 36 times as much lithium and more than four times as much cobalt as it does now. This will create a battle for resources.

According to Poul Norby, one way to ease the inevitable bottlenecks is to develop new and better battery types that use less of the raw materials that will be most in demand.

The supply challenge will, among other things, speed up the work to find alternatives to the lithium-ion batteries that are used in most electric cars today, and which still consist of approximately 10% cobalt, despite efforts to reduce the amount.



In the laboratory, Poul Norby can—among other things—measure which gaseous compounds are formed in different batteries. Credit: Bax Lindhardt

Extensive research has already been done to find alternatives to cobalt, replacing it with iron or manganese, among other things. This leads the professor to make a bold prediction:

"In five years, there will be no cobalt in our lithium-ion batteries. That's a very bold statement, but it's where we're headed, because cobalt is problematic in so many ways."

Faster development process

Battery weight, performance, and price play a big role in determining whether something is an interesting alternative to the popular lithium-ion battery. The first two parameters help ensure that electric cars can go for as long as possible on one charge.

Along with a number of DTU colleagues, Poul Norby is part of the EU's biggest and most expensive battery research project to date, the BIG-MAP. Their task is to develop an efficient process for assessing which materials are good candidates for the development of new and efficient batteries, not just for use in cars, but for the green transition in general.

"By creating an efficient process for developing, testing, and evaluating new materials, we can greatly increase the speed of the material development process. So, we're combining theoretical modeling with experimental work and creating an autonomous machine learning process that enables us to continuously evaluate and decide which way to go next," he says.

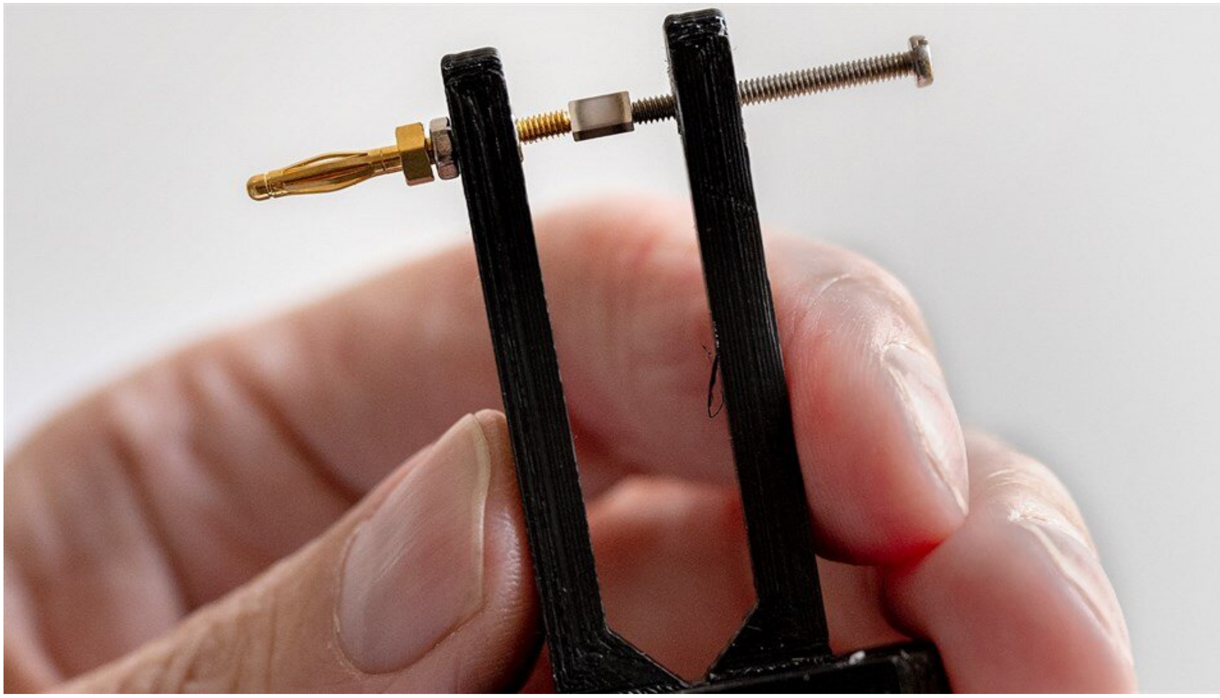
Their work contributes fundamental knowledge about materials that have a real or potential use as new or existing materials. In many ways, it is the step that comes before the development of new batteries, but it is an essential step to avoid working on ideas that ultimately turn out to be ineffective.

Next development step

According to Poul Norby, the next step in the development of new batteries is solid-state batteries. Unlike in current lithium-ion batteries, the electrolyte (i.e., the connection between the positive and negative poles of the battery) is solid instead of liquid and is made of glass, minerals or polymers.

Several major car manufacturers have invested heavily in the development of solid-state batteries, which are expected to be more fireproof, charge significantly faster, and contain twice as much energy as the lithium-ion batteries available today. Several car brands have announced that they expect to have a usable solid-state battery ready by 2025.

According to Poul Norby, the ultimate dream is to have a lithium-air battery with an energy density close to that of fossil fuels—and which does not require cobalt:



The only commercially available rechargeable solid-state battery on the marked is used in microelectronics. It supplies the device with power when it is not connected to a power outlet. Here in the laboratory, it is mounted in a device that lets the researchers conduct X-ray diffraction while the battery charges and discharges. Credit: Bax Lindhardt

"The benefits of developing a lithium-air battery have always been massive but getting there is incredibly difficult. If not for the huge benefits we stand to gain, no one would ever attempt it."

By combining calculations with experimental work, DTU researchers have shown that—in theory—it is possible to make a lithium-air battery. However, it is so far proving very difficult to achieve sufficient energy efficiency, charging speed, and durability.

"This is definitely something that could revolutionize battery technology, but it's a long way off, if it's even possible," he says.

New life for old batteries

Recirculation will also play an important part in preventing a shortage of raw materials in the long run. The aforementioned KU Leuven study estimates that if Europe invests heavily now, the continent will be able to cover 40–75% of the need for raw materials for the green transition through recycling alone.

"The public debate leaves the impression that recirculation starts here and now, but that's not true. Battery materials have been recycled for a very long time. It's been difficult and expensive so far, but the development of cheaper and more efficient recycling methods is moving fast," says Poul Norby.

Figures from the European Parliament show that in 2019, 51% of portable batteries sold in the EU were collected for recycling, but EU politicians are working to adjust the rules to ensure a higher level of recycling, including of batteries from storage and electric cars.

"Virtually all materials in batteries will have to be recycled in the future—even if it's not profitable," says Professor Norby.

Tesla and Volkswagen report that they can already recycle more than 90% of the materials in their own batteries. Of course the recycling process is undeniably easier when it comes to disassembling 500 kg batteries and sorting them into piles of usable raw materials than when handling a mixture of smaller batteries from, e.g., mobile phones and laptops, which contain different types of metals in varying amounts.

"Now we'll get these big batteries where you know exactly what's in them, how they've been treated, and what they're made of. That also makes it a lot easier to take them apart," says Poul Norby.

There are also other ways to think about recirculation of electric car batteries: When the charging capacity becomes too poor for the batteries to be used in cars, they can be used for other things such as storing power in small, local solar cell plants. A stack of used batteries can form a local storage unit for 10 to 15 years before it is necessary to take the batteries apart and use the raw materials again.

By prolonging the life of the batteries in this way, we can also buy time for the development of cheaper and better ways to recycle the raw materials.

Provided by Technical University of Denmark

Citation: Recycling and rethinking batteries (2022, October 3) retrieved 4 December 2023 from https://techxplore.com/news/2022-10-recycling-rethinking-batteries.html