Tomorrow's super battery for electric cars is made of rock

June 26 2024, by Katrine Damkjær

Making a powder based on potassium silicate. Credit: Frida Gregersen

It is the battery in your electric car that determines how far you can drive on one charge and how quickly you can re-charge. However, the lithium-ion battery, the most widely used electric car battery today, has its limitations—in terms of capacity, safety and also availability. Because lithium is an expensive, environmentally harmful material and the scarcity of the relatively rare metal can hinder the green transition of car transport.

As more and more people switch to electric cars, we need to develop a new generation of lithium-free batteries, which are at least as efficient, but more eco-friendly and cheaper to produce. This requires new materials for the battery's main components; anode, cathode, and electrolyte, as well as developing new battery designs.

It is a research field that is currently occupying researchers all over the world, because when we find new 'recipes' for batteries, it will enable a significant reduction of the transport sector's carbon emissions.

At DTU, researcher Mohamad Khoshkalam has invented a material that has the potential to replace lithium in tomorrow's super battery: solid-state batteries based on potassium and sodium silicates. These are rock silicates, which are some of the most common minerals in the Earth's crust. It is found in the stones you pick up on the beach or in your garden.

A great advantage of the new material is that it is not sensitive to air and humidity. This makes it possible to mold it into a paper-thin layer inside the battery.

Patented superionic material

The potential of the milky-white, paper-thin material based on potassium silicate is huge. It is an inexpensive, eco-friendly material that can be extracted from silicates, which cover over 90% of the Earth's surface. The material can conduct ions at around 40 degrees and is not sensitive to moisture.

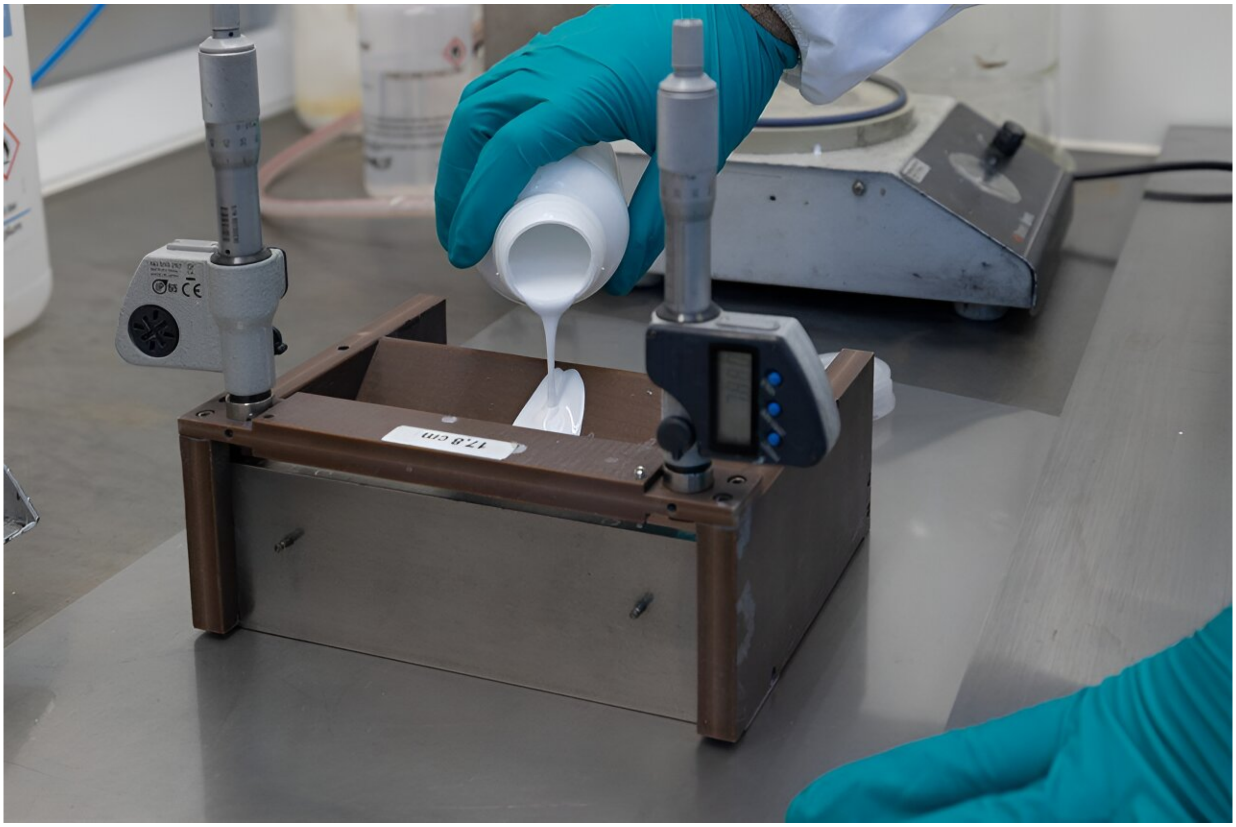
This will make scaling up and future battery production easier, safer and cheaper, as production can take place in an open atmosphere and at temperatures close to room temperature. The material also works without the addition of expensive and environmentally harmful metals such as cobalt, which is currently used in lithium-ion batteries to boost capacity and service life.

"The potential of potassium silicate as a solid-state electrolyte has been known for a long time, but in my opinion has been ignored due to challenges with the weight and size of the potassium ions. The ions are large and therefore move slower," says Mohamad Khoshkalam.

To understand the perspectives of Mohamad Khoshkalam's discovery, one must first understand the crucial role the electrolyte plays in a battery. The electrolyte in a battery can be a liquid or a solid material—a so-called solid-state electrolyte. The electrolyte allows the ions to move between the battery's anode and cathode, thereby maintaining the electrical current generated during discharging and charging. In other words, the electrolyte is crucial for the battery capacity, charging time, lifespan, and safety.

The electrolyte's conductivity depends on how fast the ions can move in the electrolyte. The ions in rock silicates generally move slower than the ions in lithium-based liquid electrolytes or solid-state electrolytes, as they are larger and heavier. But Mohamad Khoshkalam has found a recipe for a superionic material of potassium silicate and a process that makes the ions move faster than in lithium-based electrolytes.

"The first measurement with a battery component revealed that the material has a very good conductivity as a solid-state electrolyte. I cannot reveal how I developed the material, as the recipe and the method are now patented," Mohamad Khoshkalam continues.



The powder is mixed with a binder and a solvent and the liquid solution is poured onto a roller that rolls out the material in a thin layer. The quality of the solution is assessed to make a solid electrolyte with fewer defects. Credit: Frida Gregersen

The battery everyone is waiting for

Both researchers and electric car manufacturers consider solid-state batteries to be the super battery of the future. Most recently, Toyota has announced that they expect to launch an electric car with a lithium solid-state battery in 2027–28. However, several car manufacturers have previously announced electric cars with solid-state batteries, only to subsequently pull out.

In a solid-state battery, the ions travel through a solid material and not through a liquid, as in the regular AA+ lithium-ion batteries you can buy in the supermarket. There are several advantages to this; the ions can move faster through a solid material, making the battery more efficient and faster to charge.

A single battery cell can be made as thin as a piece of cardboard, where the anode, cathode, and solid-state electrolyte are ultra-thin layers of material. This means that we can make more powerful batteries that take up less space. This offers benefits on the road, as you will be able to drive up to 1,000 km on a single 10-minute charge. In addition, a solid-state battery is more fireproof, as it does not contain combustible liquid.

Before we see the solid-state battery on the market, however, there are several challenges that need to be solved. The technology works well in the laboratory, but is difficult and expensive to scale up. Firstly, materials and battery research is both complex and time-consuming because the materials are super sensitive and require advanced laboratories and equipment. The lithium-ion batteries we use today took over 20 years to develop, and we're still developing them.

Secondly, we need to develop new ways of producing and sealing the batteries so the ultra-thin material layers in the battery cell do not break and have continuous contact in order to work. In the laboratory, you solve it by pressing the layers of the battery cell together at high pressure , but it is difficult to transfer to a commercial electric car battery, which consists of many battery cells.

Solid-state rock battery is high-risk technology

Unlike lithium solid-state batteries, solid-state batteries based on potassium and sodium silicates have a low TRL (Technology Readiness Level). This means there is still a long way to go from discovery in the lab to getting the technology out into society and making a difference. The earliest we can expect to see them in new electric cars on the market is 10 years from now.

It is also a high-risk technology, where the chance of commercial success is small and the technical challenges are many. Nevertheless, Mohamad Khoshkalam is full of optimism and says, "We have shown that we can find a material for a solid-state electrolyte that is cheap, efficient, eco-friendly, and scalable—and that even performs better than solid-state lithium-based electrolytes."

A year after the discovery in the laboratory at DTU, Mohamad Khoshkalam has obtained a patent for the recipe and is in the process of establishing the start-up K-Ion, which will develop solid-state electrolyte components for battery companies.

The next step for Mohamad Khoshkalam and his team is to develop a demo battery that can show companies and potential investors that the material works. A prototype is expected to be ready within 1–2 years.

Provided by Technical University of Denmark

Citation: Tomorrow's super battery for electric cars is made of rock (2024, June 26) retrieved 29 June 2024 from https://techxplore.com/news/2024-06-tomorrow-super-battery-electric-cars.html