New material could boost batteries' power, help power plants

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You're going to have to think very small to understand something that has the potential to be very big.

A team of researchers, including Kyle Brinkman of Clemson University, developed a material that acts as a superhighway for ions. The material could make batteries more powerful, change how gaseous fuel is turned into liquid fuel and help power plants burn coal and natural gas more efficiently.

The team reported its findings Friday in the journal *Nature Communications*.

Ye Lin, Shumin Fang and Fanglin Chen, all of the University of South Carolina, collaborated with Brinkman and Dong Su, who is with the Center for Functional Nanomaterials at Brookhaven National Laboratory in Upton, New York.

To understand what they did, it helps to know how batteries and fuel cells convert chemical energy into electricity.

It goes like this: A chemical reaction splits fuel atoms into ions and electrons. The ions go through a substance called an electrolyte while electrons zip around a circuit. When the ions and electrons recombine on the other side of the electrolyte, it creates electrical power.

That's why your cell phone is able to light up or your iPod starts playing music.

Batteries and fuel cells have done some great stuff, but they are limited by how fast ions pass through the electrolyte. If you speed up the ions, you'll have a more powerful battery or fuel cell.

The challenge for engineers is finding a mix of electrolyte ingredients that allows the ions to move as quickly as possible.

Members of the research team sharpened their focus on ceria doped with with gadolinia. It's not something you buy at the local convenience store, but it's a substance well-known to materials scientists and engineers.

Seen through a highly powerful microscope, the material looks like a chessboard with many particles, or "grains," jammed together. Those grains are made of gadolinia-doped ceria, and ions zip through the grains with ease.

But there was a problem. Gadolinia tends to accumulate at the boundaries of those tiny grains, slowing down the ions.

The research team figured out that adding cobalt iron oxide to the mix cleaned out the gadolinium that had accumulated in the grain boundaries. With the new ingredient, ions had clear sailing through the electrolyte en route to their rendezvous with the electrons.

It's great for turning chemical energy into electrical power, which could result in more powerful batteries and fuel cells.

But that's not all.

Cleaning out the boundaries allowed eased movement of oxygen ions, which helps create pure oxygen. So the same material that enhances power could also be used to create membrane systems that purify gas mixtures.

It could mean that oxygen will replace steam in the process used to turn fuels into liquid, including the gasoline you put in your car. Pure oxygen is also an ideal environment for fire, so it could be used to help burn coal and natural gas.

Brinkman said he first began working on the technology when he was a post-doctoral researcher at the National Institute of Advanced Industrial Science and Technology in Japan.

He continued his work at Savannah River National Laboratory and brought it with him when he took the job at Clemson in January 2014.

Brinkman is now an associate professor in the materials science and engineering department.

"I'm proud to be a part of this collaboration," he said. "It's a great feeling to understand the principles and to know they can be applied. I think we're on the cusp of something potentially world-changing.

"The ability to control the performance of materials by tuning small interfacial regions represents a huge opportunity in the design of materials for use in energy conversion and storage."

When he first began his research, Brinkman would mix various materials together, take measurements and try to understand what happened based on equations.

But now researchers can see what is occurring at the atomic level by using Brookhaven's highly powerful electron microscopes.

Brinkman said the material that researchers used to conduct ions typically works at temperatures near 800 degrees Celsius, so it would be too hot to stick in your pocket. The next step is to work with materials that burn at cooler temperatures, he said.

Anand Gramopadhye, dean of Clemson's College of Engineering and Science, said the work was a wonderful example of two top South Carolina universities coming together for the betterment of the whole state and nation.

"The Tigers and Gamecocks may be rivals on the football field, but we come together in the lab," he said. "We are one South Carolina working toward a more sustainable nation. I congratulate the team on its work."

Provided by Clemson University

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