Building a better FUEL

by
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CELL

Thanks to a Texas A&M-CONACYT grant, researchers from the United States and Mexico are working together to improve hydrogen fuel cells that could one day diminish the world's dependence on fossil fuels while also reducing pollution.

Led by Perla Balbuena, a professor in Texas A&M University's Dwight Look College of Engineering, and Omar Solorza-Feria, a professor at the Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV-IPN) in Mexico City, the project is using different materials and techniques to make a key component of fuel cells—known as the catalyst—more effective, more durable and less expensive to produce.

Like batteries, fuel cells work by converting chemical energy into electricity. However, instead of having a fixed supply of chemicals stored inside like a battery, fuel cells use a constant flow of hydrogen and oxygen to generate electricty. This means that fuel cells produce electricity without pollution, with only water and a small amount of heat as by-products. "From the point of view of the environment this is good," Balbuena said. "It doesn't produce pollution."

Fuel cells

There are several types of fuel cells, each works in different conditions. The fuel cells Balbuena and Solorza-Feria are working on—proton exchange membrane fuel cells—work well at temperatures below 100 degrees Celsius. PEM fuel cells rely on a permeable membrane, which allows hydrogen ions to pass through to combine with oxygen with the help of a catalyst. The catalyst is made from nano-particles of noble metals, such as platinum or palladium and their alloys.

To be truly useful, fuel-cell designs need to balance their ability to generate electricity with durability and cost. They need to produce enough energy to power a car, be durable enough to keep working for years and be affordable for consumers. High production costs, mostly due to the use of platinum, have put a damper on fuel-cell adoption so far. To reduce costs, some designs use less expensive materials like iron, nickel or cobalt. But fuel-cell membranes are made of an acidic material. Catalysts made of these materials tend to dissolve. Those made of platinum or palladium, which are non-reactive, are more durable.

Balbuena and Solorza-Feria's solution is to build a catalyst using a structure made of bismuth coated with a thin layer of nanometer-scale platinum or palladium particles. This would provide adequate energy output while keeping fuel-cell production costs low enough to create a viable alternative energy source. In addition, the design would be durable because the bismuth structure is protected from the acidic membrane by its noble-metal coating.

The key is finding the best combination of materials and structure, which calls for researchers to test many different designs. This is time-consuming and expensive, which is why the project is using some of Texas A&M's expertise and computing resources to test designs with computer simulations of chemical reactions. This saves time and money by allowing the researchers to test many combinations of structure, materials and environmental conditions.

Computer simulations will narrow prospective designs to a handful of top performers for further testing at CINVESTAV-IPN. After building prototypes of these catalysts, the research team will evaluate the designs with a series of tests. First, the team will use x-ray diffraction and a high-resolution transmission electron microscope to examine the catalyst's tiny structures, morphology and chemical compositions; this will help the team to make sure it has produced

Air pollution in Mexico City is a continuing concern for citizens, health experts and environmentalists.

what it wants. After passing this thorough characterization, each prototype will go through various electrochemical tests, measuring how much energy it would produce and how much it is affected by an acidic environment.

After passing these tests, each catalyst will then be assembled with a proton exchange membrane and put into a housing to make a single and complete fuel-cell stack. The team will then install the stack in its custom-built test car and run a series of tests that mimic real-world conditions.

In addition, the collaboration benefits students at both universities. The project involves two to three graduate students, with occasional part-time undergraduate and visiting students. With research taking place in both countries, there is a great deal of communication between the schools. Balbuena said the most important aspect is the exchange of students. The grant, although limited, has allowed a student from Mexico to come to College Station for six months, providing insight into both the research at hand and international collaboration in general.

This collaborative approach will help bridge the technological gap between the two countries and will advance technology on both sides of the border by developing human infrastructure through an integrated plan.

Alloy Nanocatalysts for Fuel Cell Electrodes

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