Characterizing Nanoparticles for Fuel Cells

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The solid oxide fuel cell, which runs on hydrogen and oxygen to produce water as exhaust, is seen as a promising technology of the future for transportation. These fuel cells are now used on an experimental basis to power some city buses. But the fuel cells have proved unreliable because the nanoparticles of platinum that serve as a catalyst for the chemical reaction sometimes do not function optimally.

"Scientists want to exploit the nanoparticle in the device but still don't know that particle's basic properties," said Simon Billinge. "Sometimes it works, and sometimes it doesn't."

These catalysts, nanoparticles of platinum, are balls one-millionth of a millimeter in diameter. The properties of the metal change when they are so small and scientists have yet to fully characterize them. By determining the nanoparticle's structure and properties—its electrical conductivity, thermal conductivity, melting point, and stiffness—scientists will be better able to predict a fuel cell's performance, based on what particular nanoparticle is used as the catalyst.

To help provide a solution, Billinge is developing new methods to characterize the structure of nanoparticles, figuring out the arrangements of atoms in particles that are made up of a few hundred to a few thousand atoms. He uses intense x-ray and neutron source technology, carrying out his research using particle accelerators at the Brookhaven National Laboratory in Long Island, N.Y., the Los Alamos National Laboratory in New Mexico, and the Argonne National Laboratory in Illinois.

In these accelerators, electrons circle at high energy, emitting intense x-ray beams that impinge on the nanoparticles. The scattered x-rays interfere with each other to produce "diffraction" patterns of intensity. Billinge has made important breakthroughs by developing novel Fourier transform methods to analyze the data.

He also has worked on measuring the surface energy of the platinum catalyst. The surface atoms, like those on the meniscus of a water droplet, have higher energy than those inside of the particle. And it's the surface area of the nanoparticles that provides the reactivity for the hydrogen and oxygen that come together to produce the energy that propels the vehicle.

Earlier this year, Billinge won the J.D. Hanawalt Award for his contribution to the field of powder diffraction. The International Center for Diffraction Data gives the award every three years. Awardees are chosen by the Hanawalt Award Selection Committee, which is comprised of past recipients.

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