Brookhaven Lab Scientists Discover Gold Clusters Stabilize Platinum Electrocatalysts for Use in Fuel Cells

Platinum is the most efficient electrocatalyst for accelerating chemical reactions in fuel cells for electric vehicles. In reactions during the stop-and-go driving of an electric car, however, the platinum dissolves, which reduces its efficiency as a catalyst. This is a major impediment for vehicle-application of fuel cells.

Now, scientists at Brookhaven National Laboratory have overcome this problem. Under lab conditions that imitate the environment of a fuel cell, the researchers added gold clusters to the platinum electrocatalyst, which kept it intact during an accelerated stability test. This test is conducted under conditions similar to those encountered in stop-and-go driving in an electric car. The research is reported in the January 12, 2007, edition of the journal *Science*.

Brookhaven's Chemistry Department researchers Junliang Zhang, Kotaro Sasaki, and Radoslav Adzic, along with Eli Sutter from Brookhaven's Center for Functional Nanomaterials, authored the research paper. "Fuel cells are expected to become a major source of clean energy, with particularly important applications in transportation," said coauthor Radoslav Adzic. "Despite many advances, however, existing fuel-cell technology still has drawbacks, including loss of platinum cathode electrocatalysts, which can be as much as 45 percent over five days, as shown in our accelerated stability test under potential cycling conditions. Using a new technique that we developed to deposit gold atoms on platinum, our team was able to show promise in helping to resolve this problem. The next step is to duplicate results in real fuel cells."

A hydrogen-oxygen fuel cell converts hydrogen and oxygen into water and, as part of the process, produces electricity. Platinum electrocatalysts speed up oxidation and reduction reactions. Hydrogen is oxidized when electrons are released and hydrogen ions are formed; the released electrons supply current for an electric motor. Oxygen is reduced by gaining electrons, and in reaction with hydrogen ions, water, the only byproduct of a fuel cell reaction, is produced.

In the unique method developed at Brookhaven, the researchers displaced a single layer of copper with gold on carbon-supported platinum nanoparticles. After being subjected to several sweeps of 1.2 volts, the gold monolayer transformed into three-dimensional clusters. Using x-rays as probes at Brookhaven's National Synchrotron Light Source, a scanning transmission microscope at Brookhaven's Center for Functional Nanomaterials, and electrochemical techniques in the laboratory, the scientists were able to verify the reduced oxidation of platinum and to determine the structure of the resulting platinum electrocatalyst with gold clusters, which helped them to gain an understanding of the effects of the gold clusters.

In the Brookhaven experiment, the platinum electrocatalyst remained stable with potential cycling between 0.6 and 1.1 volts in over 30,000 oxidation-reduction cycles, imitating the conditions of stop-and-go driving. “The gold clusters protected the platinum from being oxidized,” Adzic said. “Our team’s research raises promising possibilities for synthesizing improved platinum-based catalysts and for stabilizing platinum and platinum-group metals under cycling oxidation/reduction conditions.”

This research is funded through the Department of Energy’s Hydrogen Program, which implements the President’s Hydrogen Fuel Initiative, a five-year program that began in 2003 to sponsor research, development, and demonstration of hydrogen and fuel cell technologies. Specifically, the funding derived from DOE’s Office of Basic Energy Sciences and its Office of Energy Efficiency and Renewable Energy.

PPPL's Meixler Appointed Chair of NJ Regional Homeland Security Technology Committee

Lew Meixler of Princeton Plasma Physics Laboratory has been appointed Chair of the New Jersey Regional Homeland Security Technology Committee (NJHLSTC). The Committee reports to the Director of the NJ Office of Homeland Security and Preparedness through the New Jersey Homeland Security Planning Group. The Focus of the NJHLSTC is to identify and evaluate the many initiatives underway within the state to enhance New Jersey's security profile. The membership of the NJHLSTC represents all of the state agencies, Federal laboratories and academic research institutions in New Jersey that are engaged in developing or evaluating technologies that have potential homeland security or anti-terrorism applications.

Four Northeast Region Laboratories to Receive FLC Excellence Award

When the 2007 FLC Awards for Excellence in Technology Transfer are presented in May, four of those winners will be from laboratories located in the Northeast Region.

The **Plum Island Animal Disease Center** of Greenport, New York will be honored for the development of a technology that bleeds mice humanely for research projects. The Center, affiliated with the Department of Agriculture, created a device that is a 2" strip of surgical steel with a triangular blade that controls penetration depth. Different point lengths accommodate for different size mice. The technique has increased the accuracy of experiments that require multiple samples from the same animal. This simple method to draw blood has reduced the suffering of laboratory mice. International researchers are rapidly adopting this technology and have purchased over a million lancets in less than a year.

The **US Army Research Development and Engineering Command, Natick Soldier Center** will be recognized for their technology, a portable chemical sterilizer (PCS). The Natick, Massachusetts-based laboratory created for medics a lightweight, durable, and reusable apparatus that can easily be transported and that conveniently sterilizes contaminated medical equipment without requiring electricity. Beyond the battlefield the PCS can benefit other markets such as community hospitals for emergency back-up sterilizer units, and global entities supporting worldwide disaster relief efforts and humanitarian aid in third world countries.

Another Massachusetts laboratory, the **John A. Volpe National Transportation Systems Center** in Cambridge, will receive an award for the development of Crash Energy Management (CEM) passenger rail equipment. This technology will improve the safety of cab car led passenger trains in the event of collisions with locomotive-led trains. CEM improves crashworthiness with crush zones designed to collapse in a controlled fashion during a collision, distributing the crush among the unoccupied areas of the train. New rail equipment with the CEM features is expected to be in service in 2009.

The **Naval Undersea Warfare Center Division, Newport** (Rhode Island) will be honored for the BLUE ROSE Fiber Optic Perimeter Security and Detection System. The BLUE ROSE detects an intruder via changes in the buried optical fiber caused by sound waves in the ground. The system alerts the operator with an audio alarm as well as a visual display of the location of the intrusion along the perimeter. This technology is being made available as a commercial product for perimeter security at airports, power plants, oil and gas refineries, commercial and domestic buildings, pipelines and international borders.

The FLC Northeast Regional congratulates these laboratories on a job well done.

Natick Soldier Systems Center Mission Includes Feeding the Warfighter

The human need for food, clothing, and shelter has been understood throughout the history of civilization. Providing for these very basic yet essential needs for the warfighter brings with it challenges and constraints that many take for granted. Within the U.S. Army Materiel Command (AMC), the science and technology required to provide combat feeding systems, cutting edge clothing and individual equipment, personnel and cargo airdrop, and shelter on the battlefield for today's 1.2 million warfighters is the mission of the U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) in Natick, Massachusetts.

The research, development, testing and engineering of combat feeding systems is the mission of the NSRDEC's DoD Combat Feeding Program (CFP). The NSRDEC is committed to providing revolutionary, state-of-the-art science and engineering in the development of combat rations, field food service equipment and total combat feeding systems.

The NSRDEC is responsible for the family of combat rations to include individual, group, assault and special purpose rations, including Meal Ready-toEat (MRE). The MRE replaced the Meal, Combat Individual, which some still refer to as the old "C-Ration," beginning in 1980. From its year of introduction to 1987, the MRE contained such memorable items as: Ham and Chicken Loaf, Smoky Franks, Chicken a la King and the ever popular freeze dried pork, beef and potato patties. In 1988, eight of the original 12 entrees were replaced with entrees that were slightly more identifiable, to include spaghetti and meat sauce.

The MRE had the opportunity to go to war in Operation Desert Shield and Desert Storm. Unfortunately, the initial feedback on the acceptance of the MRE wasn't very positive. A Joint Services Operational Rations Forum (JSORF) was conceived and its first meeting was held in 1991 with the objective of redesigning the MRE. JSORF membership included a voting member from each of the Services and the Defense Logistics Agency. The commitment was to dramatically improve the quality and variety of the MRE by insuring this standard individual combat ration would not remain stagnant but would reflect changes through component enhancements every year.

In order to execute this plan, industry was brought on board immediately by involving the Research and Development Associates, an organization comprised of commercial vendors who contribute to the family of combat rations. The plan was clear; the NSRDEC would lead the charge, survey warfighters in the field and identify what food items should go into the MRE. From this data, MRE components would be obtained from the commercial sector or developed at the NSRDEC.

Prototype MRE's were assembled by the industry and include those new items. One group of warfighters consumed the current MRE as the control and the other evaluated the new prototype menus and components. Surveys for the groups were developed, collected and analyzed and the data collected from the troops in the field by a team of behavioral scientists, food technologists, and NSRDEC volunteers. This entailed living with the warfighter in the field for up to ten days.

The results of the field test were presented to the JSORF with the most highly rated prototype entrees, starches, desserts, beverages, candies and snacks replacing the least acceptable items in the current MRE. These decisions were then presented to the combat ration industry to alert them of changes that had to be made to the MRE.

This process began in 1991 with the first new components appearing in the MRE in 1992 and continues today. From 1993 to 2006, over 165 new items have been included in the MRE.

In the past two years, 29 new items have been approved for the MRE for 2007 and 2008. The field test with warfighters to evaluate new components and menus for the 2009 MRE took place in Yakima, Wash., during October 2006. 23 new items have been assembled in prototype menus. The feedback from these warfighters will determine what new items will go into the MRE in 2009. All in all, more than 6,000 Warfighters, Soldiers and Marines both, have contributed to the MRE improvement program since 1992.

In the not too distant future, rations will contain naturally occurring constituents such as probiotics, which are beneficial bacteria such as those found in yogurt, and, nutraceuticals, which are small nutritional organic molecules. It is anticipated that these constituents will provide improved nutrition, cognitive and physical performance enhancement using novel nutrient delivery systems, e.g. buccal (between the cheek and gum) delivery of nutrients based on scientifically proven studies.

Rations will be packaged using polymeric films relying on nanotechnology and contain enticing aroma emitting films. These will enhance consumption as well as protect and maintain extended shelf life to insure wholesomeness and safety. New food processing methods such as high pressure processing, pulsed electric field, and microwave sterilization will bring more variety and components with higher quality than those processed today via thermostabilization.

Self heating packages, new package designs, as well as heating and cooling technologies for rations and beverages will further enhance combat feeding systems for the warfighter.