FACTS

*a passion for discovery*

BROOKHAVEN NATIONAL LABORATORY

www.bnl.gov

***Purpose:***
To find new energy sources by combining hydrogen research with nanoscience

***Sponsors:***
- BNL Laboratory Directed Research and Development program
- DOE Office of Science
- DOE Office of Energy Efficiency and Renewable Energy

***Brookhaven Lab departments:***
- Energy Sciences & Technology
- Condensed Matter Physics
- Materials Science
- Chemistry
- National Synchrotron Light Source

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Office of Science
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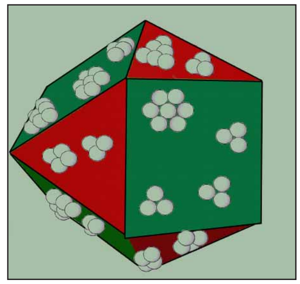
*Aerial view of Brookhaven Lab*

# Hydrogen Energy Solutions at the Nanoscale

At the U.S. Department of Energy's (DOE) Brookhaven National Laboratory, scientists are investigating ways to combine hydrogen research with nanoscience to find innovative solutions to energy problems.



*Fuel cell catalyst: a ruthenium nanoparticle dotted with platinum clusters.*

## Hydrogen Storage Materials

To develop efficient hydrogen batteries and fuel cells for powering cars, homes, and businesses, materials that can store and release a lot of hydrogen are a necessity. Recently, the DOE stated that any such materials slated for use by 2015 must have certain properties – they must be cheap, safe to handle, and have high reactivity rates and storage capacities.

At Brookhaven, scientists are attempting to meet that challenge by studying metal hydride compounds, which release hydrogen when reacted with a catalyst. With the DOE guidelines in mind, they are looking for materials that hold nine percent hydrogen by weight (a relatively large amount) and are reusable.

## Catalysts at the Nanoscale

Metal nanoparticles are good catalysts because each one provides a surface for a reaction, producing a high overall reactivity rate.

Brookhaven scientists have made a catalyst by placing clusters of platinum atoms on ruthenium nanoparticles. The platinum participates in the reaction, while the ruthenium, a much cheaper material, keeps the cost of the catalyst low.

Additional studies focus on sodium aluminum hydride, which can hold four to five percent hydrogen by weight, releasing it after reacting with a titanium catalyst. The researchers want to know why titanium works, and have postulated that the reaction may form nanoparticles of a titanium/aluminum alloy. Learning about the reaction may help them apply the same principles to materials that may have higher storage capacities.

## Finding Clean Hydrogen Sources

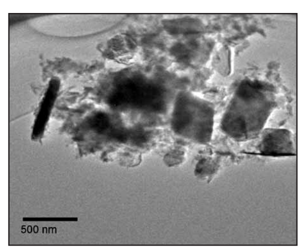
One of the roadblocks toward the practical use of hydrogen as fuel is finding a hydrogen source that doesn't produce a lot of waste. Natural gas, oil, and coal are good sources, but the reaction process is very wasteful, producing enough carbon monoxide (CO) to eventually stop the reaction entirely. In a fuel cell, this is called CO poisoning.

In the ruthenium nanoparticle research described above, the scientists also found that this catalyst lowers the CO poisoning rate, allowing the fuel cell to function longer. This research may help lead to practical fuel cells that can power cars for days instead of hours.

## Metallurgical Reactions

To be reusable, a metal hydride must release hydrogen via a reversible reaction, in which the hydride splits into hydrogen and a metal (or metal alloy), and later re-stores the hydrogen.

One such metal hydride under investigation at Brookhaven is a lithium/aluminum hydride ($LiAlH_4$), which can undergo a reversible metallurgical reaction to form LiAl "platelets" about 100 nanometers (nm) thick. These platelets may be used as electrode material in lithium batteries.




*LiAl platelets: each platelet is about 400 nm wide and 100 nm thick.*

The researchers have also designed a possible hydrogen storage system with a storage capacity of 7.5 percent hydrogen by weight. Starting with $LiAlH_4$ and titanium oxide, they postulated that the reaction process eventually produces a nanocomposite metal-alloy material that reversibly stores and releases hydrogen. This will be tested in the future.

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