

# Aluminum alloy overcomes obstacles on the path to making hydrogen a practical fuel source

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Hydrogen offers great promise as a renewable energy source. It's staggeringly plentiful (the most abundant element in the Universe) and environmentally friendly (used in a fuel cell, it gives off only water). Unfortunately, storing and transporting hydrogen for personal use is a significant engineering challenge.

Now, a team of researchers from the University of Texas at Dallas and Washington State University in Pullman, Wash., has made the counterintuitive discovery that aluminum, with a minor modification, is able to both break down and capture individual hydrogen atoms, potentially leading to a robust and affordable fuel storage system.

In nature, when two atoms of hydrogen meet they combine to form a very stable molecule ( $H_2$ ). [Molecular hydrogen](#), however, has to be stored under great pressure and at very low temperatures, which is impractical if you want to power a vehicle or provide [electricity](#) for a home. A better solution would be to find a material that, at easily maintained temperatures and pressures, could efficiently store individual hydrogen atoms and release them on demand.

The first step in this process – hydrogen activation, breaking the chemical bonds that hold two hydrogen atoms together – is typically done by exposing molecular hydrogen to a catalyst. The best catalytic materials currently available are made of so-called "noble metals" (e.g.

palladium and platinum). These elements efficiently enable hydrogen activation, but their scarcity makes them prohibitively expensive for widespread use.

In the quest to find an equally efficient yet less-expensive alternative, lead researcher Yves J. Chabal of the University of Texas at Dallas and Santanu Chaudhuri at Washington State University have identified a potential new hydrogen activation method that has the additional advantage of being an effective hydrogen-storage medium. Their proposed system relies on aluminum, a plentiful but inert metal that under normal conditions doesn't react with molecular hydrogen.

The key to unlocking aluminum's potential, the researchers surmised, is to impregnate its surface with some other metal that would facilitate the catalytic reaction. In this case, the researchers tested titanium, which is much more plentiful than noble metals and is used only sparingly in creating the titanium-doped aluminum surface.

Under very controlled temperatures and pressures, the researchers studied the aluminum surface, particularly in the vicinity of the titanium atoms, for telltale signs that catalytic reactions were taking place. The "smoking gun" was found in the spectroscopic signature of carbon monoxide (CO), which was added to the system to help identify areas of hydrogen activity. If atomic hydrogen were present, then the wavelength of light absorbed by the carbon monoxide bound to the catalytic metal center would become shorter, signaling that the catalyst was working.

"We've combined a novel infrared reflection absorption-based surface analysis method and first principles-based predictive modeling of catalytic efficiencies and spectral response, in which a carbon monoxide molecule is used as a probe to identify hydrogen activation on single-crystal aluminum surfaces containing catalytic dopants," says Chaudhuri.

Their studies revealed that in areas doped with titanium, the infrared signature of the CO shifted to shorter wavelengths even at very low temperatures. This "blue shift" was an indication that atomic hydrogen was being produced around some of the catalytic centers on an aluminum surface.

As part of a hydrogen [storage system](#), an aluminum-supported catalyst has other advantages over more expensive metals. If technical advances like this can provide a pathway for aluminum to combine with hydrogen to form aluminum hydride (a stable solid with a composition ratio of a single aluminum atom to three [hydrogen atoms](#)) and store hydrogen as a high-density solid-state material, a critical step in developing a practical fuel system can be achieved.

The titanium further advances the process by helping the hydrogen bind to the aluminum to form aluminum hydride. If used as a fuel-storage device, the aluminum hydride could be made to release its store of hydrogen by simply raising its [temperature](#).

"Although titanium may not be the best catalytic center for fully reversible aluminum hydride formation, the results prove for the first time that titanium-doped aluminum can activate hydrogen in ways that are comparable to expensive and less-abundant catalyst metals such as palladium and other near-surface alloys consisting of similar noble metals and their bimetallic analogs," Chaudhuri explains.

Irinder Chopra, the lead student in this project, will present this research at AVS' 58th International Symposium & Exhibition, held Oct. 30 – Nov. 4, 2011, in Nashville, Tenn. A paper based on this research – "Turning [Aluminum](#) into a noble-metal like catalyst for low-temperature molecular [hydrogen](#) activation" – was published online in the journal *Nature Materials* on September 25.

**More information:** The AVS 58th International Symposium & Exhibition will be held Oct. 30 – Nov. 4 at the Nashville Convention Center. Presentation SS1-TuM-4, "Turning Aluminum into a Noble-metal like Catalyst for Low Temperature Molecular Hydrogen Activation," is at 9 a.m. on Tuesday, Nov. 1.

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