Breakthrough holds promise for hydrogen's use as fuel source

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The research team had to design and build ultra-high vacuum equipment to conduct the experiments.

(PhysOrg.com) -- Imagine your car running on an abundant, environmentally friendly fuel generated from the surrounding atmosphere. Sounds like science fiction, but UT Dallas researchers recently published a paper in the journal *Nature Materials* detailing a breakthrough in understanding how such a fuel – in this case, hydrogen – can be stored in metals.

"Hydrogen, which is in abundance all around us, has shown a lot of promise as an alternative fuel source in recent years," said UT Dallas graduate student Irinder Singh Chopra. “Moreover, it’s environmentally friendly as it gives off only water after combustion.”

Chopra is part of a collaborative effort among UT Dallas, Washington State University and Brookhaven National Laboratory to find ways to store hydrogen for use as an alternative fuel.

Hydrogen has potential for use as an everyday fuel, but the problem of safely storing this highly flammable, colorless gas is a technological hurdle that has kept it from being a viable option.

“We investigated a certain class of materials called complex metal hydrides (aluminum-based hydrides) in the hope of finding cheaper and more effective means of activating hydrogen,” Chopra said.

“Our research into an aluminum-based catalyst turned out to be much more useful than just designing good storage materials,” he said. “It has also provided very encouraging results into the possible use of this system as a very cheap and effective alternative to the materials currently used for fuel cells.”

This is the first step in producing many important industrial chemicals that have so far required expensive noble-metal catalysts and thermal activation. Essentially, the process can easily break apart molecular hydrogen and capture the individual atoms, potentially leading to a robust and affordable fuel storage system or a cheap catalyst for important industrial reactions.

Chopra discovered that the key to unlocking aluminum's potential is to impregnate its surface with trace amounts of titanium that can catalyze the separation of molecular hydrogen.

“It has long been theoretically predicted that titanium-doped aluminum can be used as an effective catalyst," Chopra said. "We discovered, however, that a specific arrangement of titanium atoms was critical and made it possible to produce atomic hydrogen on aluminum surfaces at remarkably low temperatures."

For use as a fuel-storage device, aluminum could be made to release its store of hydrogen by raising its temperature slightly. This system presents a method for storing and releasing hydrogen at lower temperatures than what is currently available, which is critical for safe day-to-day applications.

To perform these experiments, Dr. Jean-Francois Veyan, a research scientist in Chabal's lab, greatly assisted Chopra in the design and construction of a sophisticated ultra-high vacuum equipment.

"A critical aspect of the work was the ability to clean single crystal aluminum samples without damaging the arrangement of the surface atoms," Veyan said. "Experience gathered from my earlier PhD work on aluminum was very important to help prepare these novel Ti-doped surfaces."

Dr. Yves Chabal, Texas Instruments Distinguished University Chair in Nanoelectronics and head of the University's Department of Materials Science and Engineering, who oversaw the research program, praised the team's achievements.

"This is a good example of the kind of collaborative research that can lead to new advances in the field," Chabal said, "and how painstaking work started five years ago can bring unexpected and exciting results."

More information: www.nature.com/nmat/journal/v1 … 1/full/nmat3123.html

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