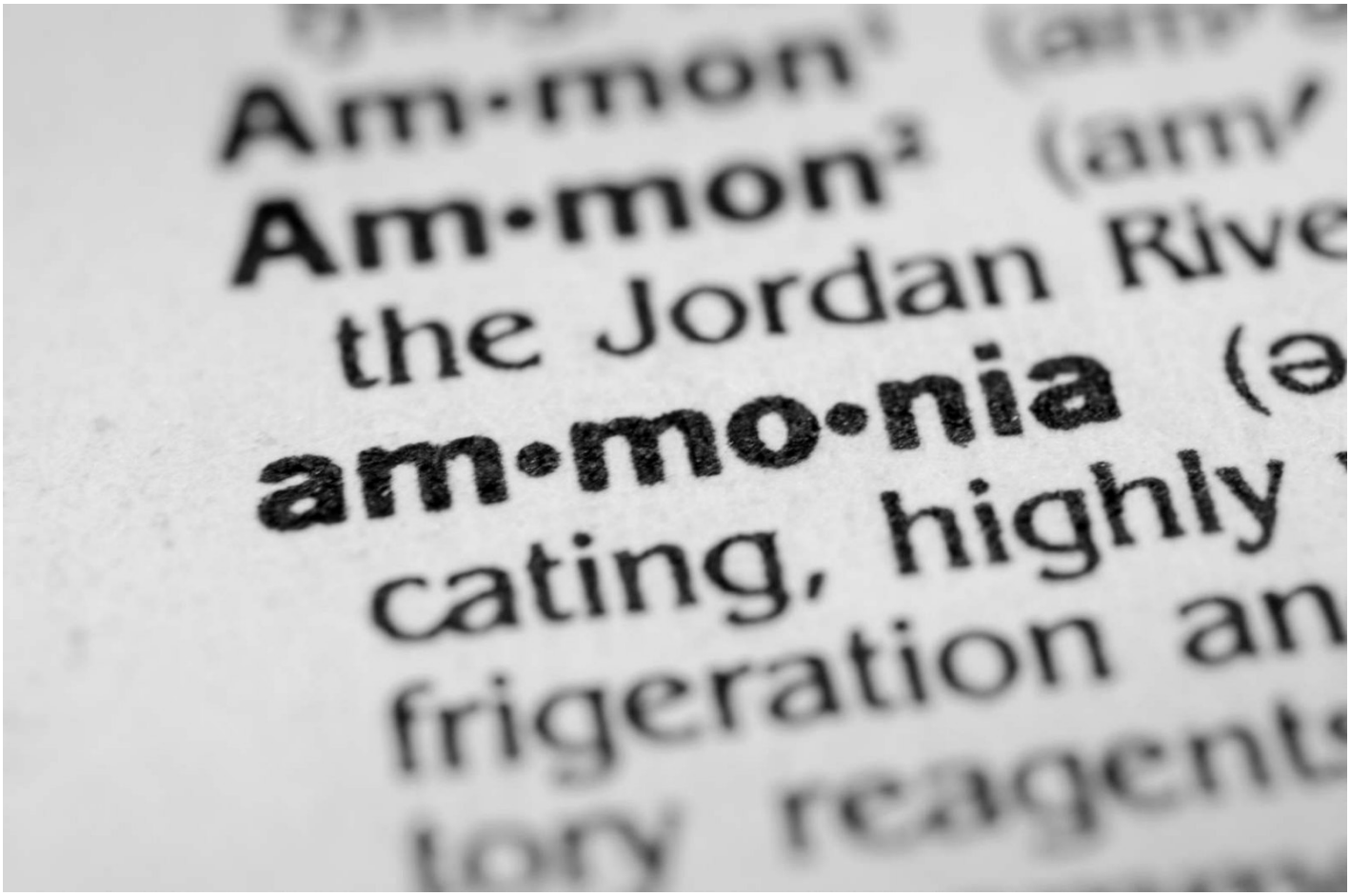
Ohio University Researcher Discovers Key To Producing Cheap Hydrogen Fuel

Ohio University



What do nuclear submarines and petrochemical plants have in common?

Both use ammonia.

Ben Schafer learned about this colorless, pungent gas during a stint as a submariner — or "bubble head" — in the U.S. Navy. Gerardine Botte, an associate professor of chemical and biomolecular engineering at Ohio

University in Athens, became familiar with it from her studies and while working in her native Venezuela.

The two ended up putting their heads together after attending a Denver meeting of the Electrochemical Society in December 2005. Botte was there representing her university's Russ College of Engineering and Technology, while Schafer was attending on behalf of his company, the Hydra Fuel Cell Corp.

The result — less than two years later — was a collaborative private sector-university partnership to develop inexpensive hydrogen from ammonia, while also producing clean wastewater in the process. This partnership led to

the establishment of a new company, American Hydrogen Corp. in the Ohio University Innovation Center, which aims to produce inexpensive hydrogen from ammonia and clean wastewater in the process.

Schafer, a computer engineer, was scouting for a cheap source of hydrogen to power small electric generators made by the Hydra Fuel Cell Corp., a subsidiary of American Security Resources Corp. (ASRC). “I’d been looking for six months,” says Schafer. “I was continually being pinged (a submariner term) by people asking me ‘where you gonna get the hydrogen?’” he says.

“Like all fuel cell companies, we’d kind of ducked the question and said the problem will get solved eventually,” he recalls. “But I was getting tired of the questions.”

Schafer knew that nuclear submarines had used ammonia in their reactors’ coolant. “We used lots of it and I was exposed to its chemistry back then,” says Schafer, a proud bubble head for seven years.

An Auspicious Lunch

Fast forward 30 years to the conference in Denver. Schafer encountered Botte and the two sat down for lunch. It was an auspicious meeting.

“I said I worked for a fuel cell company and was trying to fi nd ways to provide hydrogen,” he recalls. “She asked if I’d considered ammonia, and I told her I had, but hadn’t found a way to reduce it to nitrogen and hydrogen. She said ‘let’s talk’ and that’s how it started. It wasn’t long before we were communicating near the speed of a couple of Cray super computers.”

In a nutshell, Botte had developed a patent-pending ammonia catalytic electrolyzer (ACE) technology to efficiently convert ammonia into hydrogen.

Botte, director of Ohio University’s Electrochemical Engineering Research Laboratory came up with the idea of passing ammonia through the electrolyzer after attending a Honda Initiation Grant Conference in Columbus, Ohio, in 2002.

“One of the presenters at the conference said fuel cells are great because you start with clean water, clean energy, and in return you can produce clean water and clean power,” she recalls.

“I went back into my lab after that conference and spent the whole night doing calculations and realized that the thermodynamics of the reaction were wonderful. I said I have to work on this right away,” she says.

Botte did the initial experiments herself and then got her students involved.

“In the beginning it was like using a magnifying glass to look at little bubbles of what we have right now, which is a process that produces tons and tons of hydrogen,” she says (figuratively speaking).

“I started with an idea and a small piece of paper, which had the potential for a commercial application. And now it has become a company.”

Room Temperature

One of the things Schafer liked about Botte’s discovery is that it takes place at room temperature and under low pressure, requiring less energy and expense than high-pressure, high temperature processes.

The cost is also reasonable, too, he says.

> *It's not the horse that costs you, it's the feed. And in this case, ammonia is inexpensive. A tremendous amount of it goes into the environment as waste and we see that as a tremendous potential for recovery in energy use.*
>
> Ben Schafer

Schafer figures Botte's process involving the ammonia catalytic electrolyzer will be able to process a kilo of hydrogen for $2, far less than the $8 to $10 it costs in today's market. And a kilo of hydrogen, he notes, is the equivalent of one gallon of gas.

Schafer explains, "It's our intention to take the ACE to market in conjunction with our Hydra Fuel Cell products as the first commercial ammonia-to-energy process in the one-to-five kilowatt range.

"We also have the grander dream of really getting the hydrogen economy moving by using ammonia as the feedstock to run stationary fuel cells to supply electricity to sites and also to dispense hydrogen for hydrogen powered vehicles.

"What you store locally is ammonia and then convert it to hydrogen for your vehicle," he says. "Or you store ammonia in a gas tank and convert it onboard to feed an electric fuel cell."

Environmental Benefits and Profitable Solutions

The sources of ammonia are wide ranging, according to Botte.

"There is a lot of ammonia in the waste slurry from animals, for example, and it is a byproduct of plenty of other processes," she says. But on the drive back from the Columbus conference in 2002 to her Ohio University campus in Athens, she says she had an epiphany.

"I said 'wow,' ammonia from wastewater would be a wonderful source to produce hydrogen because it is abundant and independent of fossil fuels," she says.

"And if I put the wastewater through an electrolyzer. I remove the ammonia waste from the water and produce clean power and clean water," she says. "It is a beautiful picture."

Besides the obvious environmental benefits of removing ammonia from wastewater, there are great benefits for companies that have to dispose of ammonia they use or produce as a byproduct in their manufacturing processes. In some cases, this disposal can be costly, and can require additional time and resources. But now there's an alternative.

Instead of spending money on ammonia disposal, these companies could potentially use the ammonia catalytic electrolyzer to remove ammonia and resell it to companies that can use it to produce hydrogen, or they might even convert it to hydrogen themselves and resell it. Bottom line, it amounts to transforming a costly waste item into a profitable commodity.

"The great thing about this is that it can go so many places. It could drive a car or even be in a shuttle in a mission to Mars in the future," she says. Botte says the ACE technology dovetailed with other work she had been doing in her lab during the past several years, such as hydrogen storage.

Schafer, who likes to move fast, visited Ohio University not long after the Denver conference. He toured Botte's facilities and went back to his board seeking $50,000 to fund a project to scale up her "lab project" from 250 milliwatts to five watts.

The results, he says, were “impressive.”

Fruitful Negotiations = Collaborative Relationship

Ohio University’s Technology Transfer Office and ASRC soon entered negotiations to license Botte’s technology. As a result, the university had a substantial license package, including up-front payment, minimum annual licensee payments, running royalties for fuel cells and hydrogen production, and a sizable equity stake in ASRC for the Ohio University Foundation. And, just as important, Botte’s lab had a two-year, $600,000 sponsored research contract to support her ACE-related research and development project.

At the same time, ASRC created American Hydrogen Corp., which has exclusive worldwide rights to commercialize the technology for hydrogen production and fuel cell applications, and set up the new company in Athens at the Ohio

University Innovation Center, further strengthening the collaborative ties between ASRC and the university.

Robert Malott, associate director for technology commercialization at the university, says gaining equity in ASRC was a key to the deal. In addition to American Hydrogen and Hydra Fuel Cell, ASRC also owns a third company called American Wind Power. ASRC may also make more acquisitions in the energy field, he said.

Malott says the collaboration between the university and ASRC and American Hydrogen Corp. has gone well.

“We liked Ben’s demeanor and found him and the others we dealt with to be straightforward and down-to-earth, the kind of people we like to do business with,” Malott recalls. “There was no “smoke and mirrors” or any game-playing.”

Schafer agrees.

“It’s been great dealing with the Ohio University folks,” he says. “And their Innovation Center, especially if you are in the early stages of starting up a company, is super. The flexibility is nice and you can’t beat the cost in terms of services that are available. It takes a lot of the pain out of being a startup, that’s for sure.”

Botte, a consultant for American Hydrogen, is pleased, too. Not only is her future research being solidly funded, but her graduate students are finding work at the fledgling company.

“There is a lot of interaction between their personnel, myself and my students,” she says. “And I’m advising them on different market and R&D opportunities for the project.

“I think I will always be a professor,” she says. “But I have some ideas for the future of additional things I’d like to start.”

This story was originally published in 2008.

To see available technologies from research institutions, click here to visit the AUTM Innovation Marketplace.