

By Charles Piddock



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LIQUID GOLD

Is urine the natural resource of tomorrow?

Environmentalists envision a “green” future. They picture a world in which cars, homes, and industry rely on clean, abundant, renewable resources, such as wind and solar radiation. That future might be as much yellow as green, though, thanks to another natural resource: urine.

Earth’s nearly 8 billion people flush away an estimated 10 billion liters (2.6 billion gallons) of urine every day. Domestic mammals such as cows and pigs may release twice as much. Geraldine Botte, a chemical engineer at Ohio University, thinks throwing all that urine away wastes a golden opportunity. Urine contains what some scientists have called “the fuel of the future.” That fuel is hydrogen.

“We believe we have made a breakthrough,” says Professor Botte.

WEAK BONDS

Hydrogen is the most abundant element in the universe. It isn’t easy to access, though. It doesn’t exist alone, but rather in combination with other hydrogen atoms or other elements. An economical way must be found to break those chemical bonds. That’s what Botte and her team have attempted with urine.

Urine is made up chiefly of water, ammonia, and *urea*. Urea is a waste product released by the liver. As you can see from urea’s chemical formula— $\text{CH}_4\text{N}_2\text{O}$ —the compound’s molecules contain hydrogen atoms. Those atoms are much more loosely bound to each molecule than they are in many other compounds.

Botte and her team have developed a *catalyst* that prompts urea to quickly release its hydrogen. A catalyst is a substance that starts or speeds up a chemical reaction while undergoing no change itself. “Our process could lead the way to using urine on a wide scale to obtain

pure hydrogen," she says. "[It] works at a small fraction of the cost of other ways of obtaining hydrogen."

Once hydrogen is captured, it can then be supplied to *fuel cells*, devices that generate electricity through a chemical reaction. Some scientists have touted hydrogen fuel cells as the best replacement for today's generators and engines, which run on *fossil fuels* (coal, oil, and natural gas). Fossil fuels release air pollutants and carbon dioxide, the greenhouse gas most scientists blame for global warming. Fuel cells release no pollution. And their only by-products are water and heat.

Hydrogen fuel cells power the space shuttles' electrical systems. They also run a number of experimental vehicles, including motor scooters and small airplanes. General Motors, Ford, and Honda have each built hydrogen-powered electric cars. As of last year, however, only about 200 hydrogen-powered vehicles had hit U.S. streets and highways, all of them in California.

Most hydrogen is obtained at a very high cost from fossil fuels and from water. Once the hydrogen is separated, it must then be stored, generally as liquid hydrogen under high pressure at a very low temperature. Unless a network of stored-hydrogen "gas stations" can be developed, mass-produced electric vehicles powered by fuel cells remain a dream.

HYDROGEN STATIONS

Urine could make that dream possible. Theoretically, motorists might one day drive up to a "gas station" that dispenses hydrogen fuel derived from urea using a refining process based on Botte's research.



Botte and her team are currently working with the U.S. Army to develop a portable electric generator. It will not only process urine into electric power for Army units but also purify urine into clean water.

Another group of scientists, led by Shanwen Tao at Heriot-Watt University in Scotland, is working on a similar urine-based power source that doesn't produce hydrogen. It uses urine directly to generate electricity. So far, Tao's experiments have yielded only weak electric power from urine. He hopes that further research will produce more impressive results, making urine-run fuel cells a popular source of electricity.

COW POWER

Botte believes the day is not far off when farms will generate their own electricity from urine. "The urine produced by cows on a dairy farm, for instance, could be used to produce all the energy needed to run the farm," she says. The same holds true for office buildings and other places where large numbers of people live or work together, she says.

Neither Botte nor Tao believes that urine will ever meet all renewable energy needs. Still, it could be an important part of the clean energy mix that the world needs along with other types of energy.

"Trying to find one solution is not the answer," says Botte. "There is room for many energy technologies, but energy from urine should have its place." **CS**

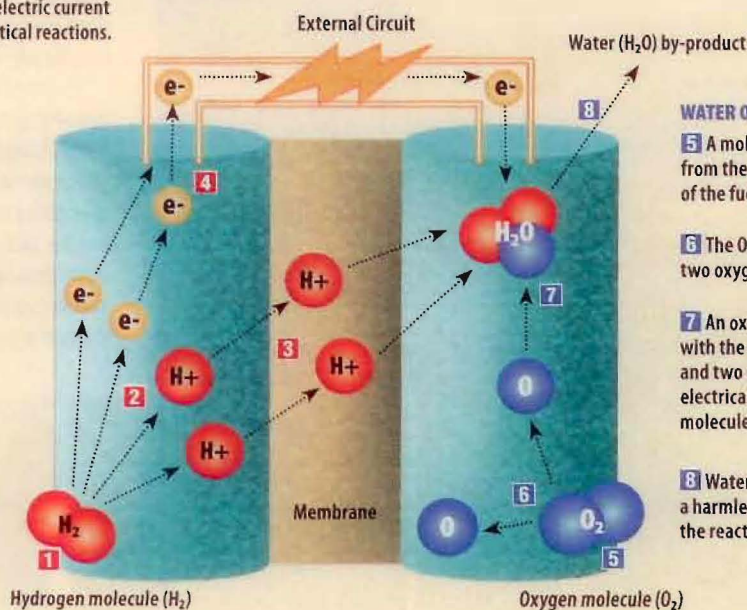
Top: Ohio University; Graphic: Leigh Haeger

How a Hydrogen Fuel Cell Works

A hydrogen fuel cell produces an electric current (and water) from a stream of identical reactions. Here is the basic reaction.

HYDROGEN IN

- 1 A molecule of hydrogen gas (H_2) is pumped into one side of the fuel cell.
- 2 The H_2 molecule splits into two hydrogen ions (H^+) and two electrons (e^-). An ion is an atom that has gained or lost one or more electrons.
- 3 The hydrogen ions move through a membrane.
- 4 The electrons bypass the membrane and move through an external circuit, creating an electric current that can be used to run an electric motor.



WATER OUT

- 5 A molecule of oxygen gas (O_2) from the air enters the other side of the fuel cell.
- 6 The O_2 molecule splits into two oxygen (O) atoms.
- 7 An oxygen atom combines with the two hydrogen ions and two electrons from the electrical circuit to form a molecule of water (H_2O).
- 8 Water is released as a harmless by-product of the reaction.