NewScientist Environment

A fuel tank full of water

- 01 August 2006
- Exclusive from New Scientist Print Edition. Subscribe and get 4 free issues
- **David Adam**

Zero-emmission transport system

Forget cars fuelled by alcohol and vegetable oil. Before long, you might be able to run your car with nothing more than water in its fuel tank. It would be the ultimate zero-emissions vehicle.

While water, plain old H_2O, is not at first sight an obvious power source, it has a key virtue: it is an abundant source of hydrogen, the element widely touted as the green fuel of the future. If that hydrogen could be liberated on demand, it would overcome many of the obstacles that till now have prevented the dream of a hydrogen-powered car becoming reality. Producing hydrogen by conventional industrial means is expensive, inefficient and often polluting. Then there are the problems of storing and transporting hydrogen. The pressure tanks required to hold usable quantities of the fuel are heavy and cumbersome, which restricts the car's performance and range.

Tareq Abu-Hamed, now at the University of Minnesota, and colleagues at the Weizmann Institute of Science in Rehovot, Israel, have devised a scheme that gets round these problems. By reacting water with the element boron, their system produces hydrogen that can be burnt in an internal combustion engine or fed to a fuel cell to generate electricity. "The aim is to produce the hydrogen on-board at a rate matching the demand of the car engine," says Abu-Hamed. "We want to use the boron to save transporting and storing the hydrogen." The only by-product is boron oxide, which can be removed from the car, turned back into boron, and used again. What's more, Abu-Hamed envisages doing this in a solar-powered plant that is completely emission-free.

Simple chemistry

The team calculates that a car would have to carry just 18 kilograms of boron and 45 litres of water to produce 5 kilograms of hydrogen, which has the same energy content as a 40-litre tank of conventional fuel. An Israeli company has begun designing a prototype engine that works in the same way, and the Japanese company Samsung has built a prototype scooter based on a similar idea.

The hydrogen-on-demand approach is based on some simple high-school chemistry. Elements like sodium and potassium are well known for their violent reactions with water, tearing hydrogen from its stable union with oxygen. Boron does the same, but at a more manageable pace. It requires no special containment, and atom for atom it's a light material. When all the boron is used up, the boron oxide that remains can be reprocessed and recycled.

Abu-Hamed and his team are not the first to investigate hydrogen-on-demand vehicles. The car giant DaimlerChrysler built a concept vehicle called Natrium (after the Latin word for sodium, from which the element's Na symbol is drawn), which used slightly more sophisticated chemistry to generate its hydrogen. Instead of pure water as the source of the gas, it used a solution of the hydrogen-heavy compound sodium borohydride. When passed over a precious-metal catalyst such as ruthenium, the compound reacts with water to liberate hydrogen that can be fed to a fuel cell. It was enough to give the Natrium a top speed of 130 kilometres per hour and a respectable range of 500 kilometres, but DaimlerChrysler axed the project in 2003 because of difficulties in providing the necessary infrastructure to support the car in an efficient, environmentally friendly way.

Engineuity, an Israeli start-up company run by Amnon Yogev, a former Weizmann Institute scientist, is working on a similar strategy, but using the reaction between aluminium wire and water to generate hydrogen. In Engineuity's design, the tip of the metal wire is ignited and dipped into water to begin splitting the water molecules. The liberated hydrogen is piped into the engine alongside the resulting steam, where it is mixed with air and burnt. Engineuity is looking for investors to pay for a prototype, and claims it will be able to commercialise its idea "in a few years' time". The US company PowerBall Technologies envisages a hydrogen-on-demand engine containing plastic balls filled with sodium hydride powder that are split to dump the contents into water, where it reacts to produce hydrogen.

Abu-Hamed says the generation of hydrogen for his team's engine would be regulated by controlling the flow of water into a series of tanks containing powdered boron. To kick-start the reaction, the water has to be supplied as vapour heated to several hundred degrees, so the car will still require some start-up power, possibly from a battery. Once the engine is running, the heat generated by the highly exothermic oxidation reaction between boron and water could be used to warm the incoming water, Abu-Hamed says. Alternatively, small amounts of hydrogen could be diverted from the engine and stored for use as the start-up fuel. Water produced when the hydrogen is burnt in an internal combustion engine or reacted in a fuel cell could be captured and cycled back to the vehicle's tank, making the whole on-board system truly zero-emission.

Hydrogen-on-demand, whether from water or another source, could address two of the big problems still holding back the wider use of hydrogen as a vehicle fuel: how to store the flammable gas, and how to transport it safely. Today's hydrogen-fuelled cars rely on stocks of gas produced in centralised plants and distributed via refuelling stations in either liquefied or compressed form. Neither is ideal. The liquefaction process eats up to 40 per cent of the energy content of the stored hydrogen, while the energy density of the gas, even when compressed, is so low it is hard to see how it can ever be used to fuel a normal car.

Hydrogen-on-demand would not only remove the need for costly hydrogen pipelines and distribution infrastructure, it would also make hydrogen vehicles safer. "The theoretical advantage of on-board generation is that you don't have to muck about with hydrogen storage," says Mike Millikin, who monitors developments in alternative fuels for the Green Car Congress website. A car that doesn't need to carry tanks of flammable, volatile liquid or compressed gas would be much less vulnerable in an accident. "It also potentially offsets the requirements for building up a massive hydrogen production and distribution infrastructure," Millikin says.

There is a potentially polluting step that has to be tackled. "You'll need an infrastructure to produce and distribute whatever the key elements of the generation system might be," Millikin warns. While Abu-Hamed's scheme still requires a distribution network and reprocessing plant, he has devised an ingenious plan that will allow the spent boron oxide to be converted back to metallic boron in a pollution-free process that uses only solar energy (see Diagram). Heating the oxide with magnesium powder recovers the boron, leaving magnesium oxide as a by-product. The magnesium oxide can then be recycled by first reacting it with chlorine gas to produce magnesium chloride, from which the magnesium metal and chlorine can then be recovered by electrolysis.

Solar source

The energy to drive these processes would ultimately come from the sun. The team calculates that a system of mirrors could concentrate enough sunlight to produce electricity from solar cells with an efficiency of 35 per cent. Overall, they say, their system could convert solar energy into work by the car's engine with an efficiency of 11 per cent, similar to today's petrol engines.

Experts are sceptical that we'll be seeing cars running on water any time soon. "It's not the kind of thing you're going to see appearing in a car in five or even ten years' time," says Jim Skea, research director at the UK Energy Research Centre in London. For example, DaimlerChrysler is now focusing its efforts on cars running on compressed hydrogen because filling stations that supply it already exist in some places.

Proponents of cars that run on water are banking that long term the idea will win out. Engineuity's Yogev claims the running costs will be comparable to those of today's petrol engines and expects to have a prototype built within three years.

My other car runs on water? Don't bet against it.