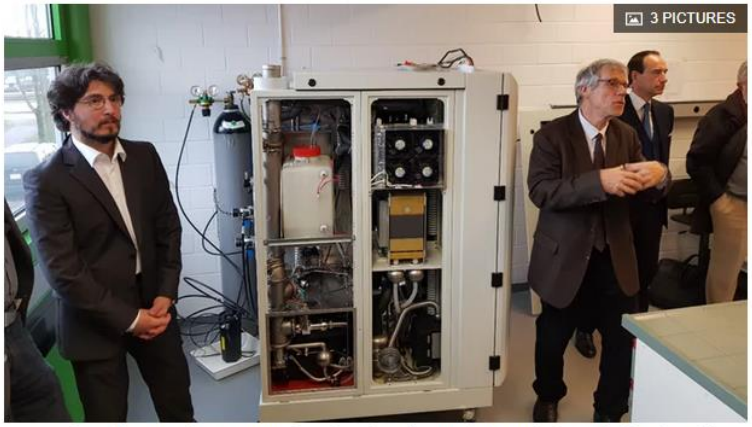
Formic acid fuel cell carries hydrogen over infrastructure obstacles

Michael Irving | March 22nd, 2018



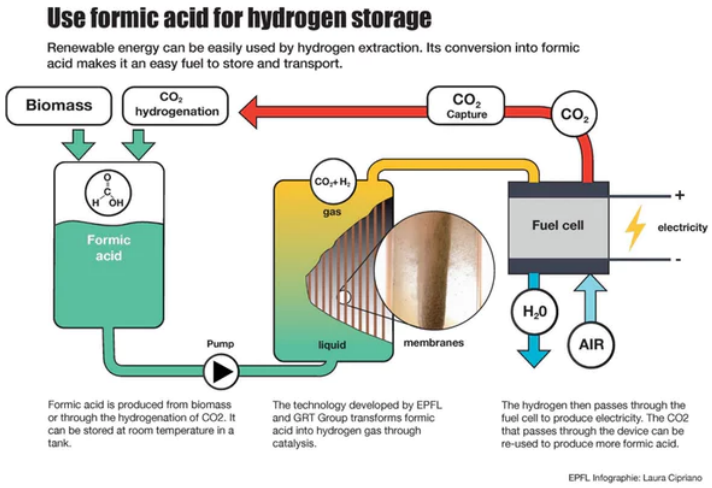
Researchers at EPFLand GRT Group have developed a promising prototype of a formic acid-based fuel cell. From left: Dr. Nordahl Autissier, GRT Group Senior Project manager; Prof Laurenczy, EPFL, Prof Eng. Luca Dal Fabbro, GRT Group CEO. (Credit: E. Barraud / EPFL)

Hydrogen fuel cells have long been floated as a potential platform for zero-emission vehicles, but problems with efficiency and storage have put up some roadblocks. Rather than using hydrogen in its normal gaseous state, a liquid hydrogen carrier called formic acid has been proposed, and now researchers from GRT Group and EPFL have built a prototype of a formic acid-based fuel cell.

The uptake for hydrogen fuel cells, both in vehicles and larger industrial uses, has been slow. It's difficult to set up the infrastructure to store and transport the gas, since it needs to be stored under high pressure and can't use the same piping as natural gas. Its fairly low energy density doesn't help, either.

Formic acid could be a more practical solution. It's the simplest combination of hydrogen and carbon dioxide and exists as a liquid under normal conditions, meaning it could slot into existing infrastructure more readily than hydrogen gas. Plus, because it's already widely used in agriculture and industry, the production infrastructure is already in place, and it could soon be made from CO2 using solar power.

Not only does formic acid make hydrogen easier to store and transport, it's a very efficient hydrogen carrier, with 1 L (0.3 gal) of formic acid carrying 590 L (156 gal) of hydrogen. That means hydrogen could be stored in a liquid form, pumped into a device to extract it as a gas, and then fed into a conventional hydrogen fuel cell. Last year, TU Eindhoven students developed just such a system that could be towed behind a bus, feeding hydrogen into its fuel cell to extend the vehicle's range.



The device works on a similar design. Formic acid is stored until needed, then pumped into a hydrogen reformer (HYFORM). Here, a ruthenium-based catalyst turns the liquid into CO2 and hydrogen gases, which is then fed into a proton-exchange membrane fuel cell (PEMFC) to produce electricity. Water and CO2 are produced as waste products, but the team says the latter can be captured and recycled through the system, by hydrogenating the gas to create more formic acid.

In its current form, the HYFORM-PEMFC system can produce 7,000 kWh of electricity every year, boasting a nominal power of 800 W and an electrical efficiency of 45 percent. The team says the fuel cell design has zero carbon dioxide balance, doesn't produce particles or nitrogen oxides, and is completely environmentally friendly if the formic acid is sourced responsibly - either using the CO2 waste from the device or by oxidating biomass.

The system is low maintenance, scalable and doesn't need any external power source, according to the researchers. The ruthenium catalyst is long-lasting and relatively inexpensive, but the team is currently working on an even cheaper alternative.