Green machine: Cars could run on sunlight and CO2

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Greenhouse-gas-pumping cars are, let's face it, never going to be green. But innovative sunlight-powered fuel production techniques could inch motor vehicles towards carbon neutrality.

Experimental solar-powered reactors have shown they can create the building blocks for synthetic liquid fuels [1]. They've got a way to go, but these projects could take a big chunk out of net carbon dioxide emissions without the need for major changes to either vehicles or refuelling infrastructure.

A team at Sandia National Laboratories [2] in Albuquerque, New Mexico, is developing a technique to create some of the ingredients for synthetic fuels from carbon-containing gases. Their cerium-oxide-based system can convert CO_2 into carbon monoxide, and can also turn water into hydrogen.

Heliocentric orbits

The machine, called the Counter Rotating Ring Receiver Reactor Recuperator (CR5) consists of two chambers separated by rotating rings of cerium oxide. As the rings spin, a large parabolic mirror concentrates solar energy onto one side, heating it to 1500 °C and causing the cerium oxide there to release oxygen gas into one of the chambers, whence it is pumped away.

As the ring rotates further it takes the deoxygenated ring off the heat and allows it to cool before it swings round to the other chamber. CO_2 is pumped into the second chamber, causing the cooled cerium to steal back an oxygen molecule, producing carbon monoxide and cerium oxide.

The process also works with water instead of CO_2, with the reaction this time producing hydrogen.

Experiments late last year with a 14-ring reactor have demonstrated that the process can produce carbon monoxide, although the failure of certain parts meant the device did not operate continuously for more than a few seconds at a time.

Bigger and better

The team is now working to improve reliability while building a bigger reactor with 28 rotating rings. That will enable it to process more CO_2 and water, says James Miller [3], a combustion chemist at Sandia.

Once the reactor is producing a steady stream of hydrogen and carbon monoxide, the gases can be converted into a synthetic liquid fuel using a technique such as the Fischer-Tropsch [4] process developed in Germany in the 1920s. In this process the two gases are heated in the presence of an iron-based catalyst to produce hydrocarbon fuels.

Initially, the team plan to use CO_2 captured from power-plant exhaust flues to produce their synthetic fuel.

Ultimately, however, they hope to use CO_2 extracted directly from the air, although they are not developing their own carbon-capture technique to do so. "That is a huge challenge in itself, and we opted to focus on one hard problem at a time," says Miller.

Cunning with calcium

Such challenges haven't deterred Aldo Steinfeld [5] and his team at the Swiss Federal Institute of Technology, Zurich. They have a system which is already sucking CO_2 out of the atmosphere to feed a synthetic fuel process.

The team's reactor again uses a large parabolic mirror to concentrate solar heat onto a chamber – this time containing calcium oxide. Once it reaches 400 °C, air is pumped into the chamber, and the heat causes the calcium oxide to react with CO_2 to form calcium carbonate.

Next, the calcium carbonate is then heated again, this time to 800 °C, at which point it releases a pure stream of CO_2 and reverts back to calcium oxide [6].

This stream of CO_2 is piped into a second reactor. Here, a solar concentrator is used to heat zinc oxide to 1700 °C, causing it to release oxygen molecules, leaving metallic zinc. The temperature is then lowered and CO_2 and steam are pumped in, which react with the pure zinc to form syngas, a mixture of hydrogen and carbon monoxide, – and zinc oxide once again. The team has previously experimented with a 10-kilowatt prototype, and is planning to test a 100-kilowatt version early next year.

Finding ways to use the sun's energy to create fuel should be one of the highest-priority areas for clean-energy technology research, says Ken Caldeira [7] of the Carnegie Institution of Washington at Stanford University in California. "This area holds out the promise for technologies that can produce large amounts of carbon-neutral power at affordable prices, which can be used where and when that power is needed," he says.

"It is one of the few technology areas that could truly revolutionise our energy future."

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