New catalysts may create more, cheaper hydrogen

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A new class of catalysts created at the U.S. Department of Energy's Argonne National Laboratory may help scientists and engineers overcome some of the hurdles that have inhibited the production of hydrogen for use in fuel cells.

Argonne chemist Michael Krumpelt and his colleagues in Argonne's Chemical Engineering Division used "single-site" catalysts based on ceria or lanthanum chromite doped with either platinum or ruthenium to boost hydrogen production at lower temperatures during reforming. "We've made significant progress in bringing the rate of reaction to where applications require it to be," Krumpelt said.

Most hydrogen produced industrially is created through steam reforming. In this process, a nickel-based catalyst is used to react natural gas with steam to produce pure hydrogen and carbon dioxide.

These nickel catalysts typically consist of metal grains tens of thousands of atoms in diameter that speckle the surface of metal oxide substrates. Conversely, the new catalysts that Krumpelt developed consist of single atomic sites imbedded in an oxide matrix. The difference is akin to that between a yard strewn with several large snowballs and one covered by a dusting of flakes. Because some reforming processes tend to clog much of the larger catalysts with carbon or sulfur byproducts, smaller catalysts process the fuel much more efficiently and can produce more hydrogen at lower temperatures.

Krumpelt's initial experiments with single-site catalysts used platinum in gadolinium-doped ceria that, though it started to reform hydrocarbons at temperatures as low as 450 degrees Celsius, became unstable at higher temperatures. As he searched for more robust materials that would support the oxidation-reduction reaction cycle at the heart of hydrocarbon reforming, Krumpelt found that if he used ruthenium – which costs only one percent as much as platinum – in a perovskite matrix, then he could initiate reforming at 450 degrees Celsius and still have good thermal stability.

The use of the $LaCrRuO_3$ perovskite offers an additional advantage over traditional catalysts. While sulfur species in the fuel degraded the traditional nickel, and to a lesser extent even the single-site platinum catalysts, the crystalline structure of the perovskite lattice acts as a stable shell that protects the ruthenium catalyst from deactivation by sulfur.

Source: Argonne National Laboratory