A long-lived catalyst facilitates the first steps toward small-scale hydrogen generator

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An iron-promoted rhodium-based catalyst is a key step forward for the realization of small-scale on-board reformers to convert biomass into hydrogen fuel for powering vehicles. Credit: Ryan McVay/Photodisc/Thinkstock

A*STAR researchers are helping to advance the development of hydrogen-powered cars by producing innovative materials that could make on-board hydrogen generators a reality. Hydrogen is a renewable resource with the potential to power everything from households to cars, but its use is currently limited by a lack of green and practical production methods.

Current approaches to generating hydrogen as a power source are anything but environmentally friendly. Obtaining hydrogen through steam reforming and electrolysis of water—the splitting of water into hydrogen and oxygen by applying an electric current—requires high energy input and fossil fuels. In contrast, the process of ethanol steam reforming (ESR) uses ethanol derived from renewable biomass to produce hydrogen and other products.

One drawback of ESR, however, is that it requires high reaction temperatures to proceed and therefore a catalyst is needed to spur on the reaction. Another downside of ESR is that it often produces carbon monoxide as a byproduct, which is toxic and can also lead to poisoning of hydrogen fuel cells.

Luwei Chen, Armando Borgna and colleagues at the A*STAR Institute of Chemical and Engineering Sciences have developed an iron-promoted rhodium-based catalyst on a calcium-modified aluminum oxide support for ESR. This catalyst enables hydrogen to be generated more efficiently with less environmental damage as the reaction can occur at temperatures as low as 350 degrees Celsius and produce almost no carbon monoxide as a byproduct. The presence of iron oxide enables carbon monoxide to be converted into carbon dioxide and hydrogen via a reaction known as the water–gas shift reaction. Thus, the iron promotion effect on the rhodium-based catalyst is the key to removing carbon monoxide—something that is exceedingly difficult to achieve on rhodium alone.

Additional benefits of ESR are the commercial advantages stemming from the catalyst being quite stable and having a long active lifetime. This means that the catalyst will permit long cycle lengths, minimize the regeneration frequency and reduce the operational downtime for on-board steam reformers. Chen explains that these factors are "essential for maintaining profitable operations in reforming units. Similarly, a stable catalyst would reduce the operating cost for an on-board reformer."

Chen notes that the catalyst will enable "better operational flexibility in terms of economics and on-board reformer size (since carbon monoxide purification units can be removed)," which she says will "make a significant impact in the design of efficient and simple on-board reactors." Hence, this research is promising for advancing the realization of small-scale on-board reformers for hydrogen-powered cars.

More information: Choong, C. K. S., Chen, L., Du, Y., Wang, Z., Hong, L. & Borgna, A. "Rh–Fe/Ca–Al2O3: A unique catalyst for CO-free hydrogen production in low temperature ethanol steam reforming." *Topics in Catalysis* 57, 627–636 (2014). dx.doi.org/10.1007/s11244-013-0221-0

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