Converting bioethanol into hydrogen for fuel cells becomes significantly simpler with innovative metal catalysts

June 19 2013

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A process known as ethanol steam reforming is creating opportunities for fuel cell researchers, thanks to the recent rise of the bioethanol industry. This technique generates hydrogen gas (H_2) directly within fuel cell systems onboard vehicles by decomposing bioethanol in the

presence of special catalysts—an approach that could use current gasoline delivery infrastructures to power alternative energy transportation. Currently, ethanol steam reforming suffers from a major obstacle: its multiple reaction pathways can produce toxic carbon monoxide (CO) byproducts that ruin fuel cell membranes.

Lin Huang, Jianyi Lin and co-workers from the A*STAR Institute of Chemical and Engineering Sciences in Singapore have now prepared a novel metal catalyst that can eradicate CO emissions from ethanol-derived H2 at temperatures 50 °C lower than previous catalysts.

Low-temperature ethanol steam reforming boosts the safety and efficiency of fuel processing onboard vehicles, but requires a careful choice of catalysts. Rhodium (Rh), a relatively scarce transition metal, has gained attention among chemists because it targets ethanol's carbon–carbon bond—the most difficult part of the alcohol to decompose. However, Rh catalysts tend to generate CO and methane byproducts when steam reforming conditions fall below 350 °C.

Huang, Lin and co-workers investigated whether they could resolve Rh's shortcomings with cobalt (Co), a less expensive transition metal that has high selectivity toward H2 production at low temperatures. They explored whether Co could be combined with Rh on a nanostructured oxide surface to produce a dual-component catalyst. While making a mixed catalyst is relatively straightforward, finding one that maximizes the benefits of both metals for efficient steam reforming is not as easy. Therefore, the team investigated how different metallic precursors could achieve an ideal interaction between Rh and Co atoms on the supporting surface.

Their experiments revealed that catalysts consisting of Rh and Co, prepared from metal carbonyl precursors, gave high yields of extraordinarily clean H2 with no CO emissions at temperatures as low as

300 °C. According to Huang, these findings indicate that atomic interactions between the metals favor a particular pathway, known as the water–gas shift, which converts CO and water into H2 and carbon dioxide. However, mixed catalysts made from metal nitrate precursors failed to yield CO-free H2, presumably because of poor atomic interactions.

The team now faces two challenges: uncovering the mechanistic reasons why supported Rh–Co dual-component catalysts are so effective; and, reducing the build-up of carbonaceous coke deposits that adversely affect catalytic activity and stability during ethanol steam reforming.

More information: Huang, L., Choong, C., Chen, L., Wang, Z., Zhong, Z., Campos-Cuerva, C. & Lin, J. Monometallic carbonyl-derived CeO2-supported Rh and Co bicomponent catalysts for CO-free, high-yield H2 generation from low-temperature ethanol steam reforming. *ChemCatChem* 5, 220–234 (2013). dx.doi.org/10.1002/cctc.201200452

Provided by Agency for Science, Technology and Research (A*STAR), Singapore