A way to use water to convert methane into methanol

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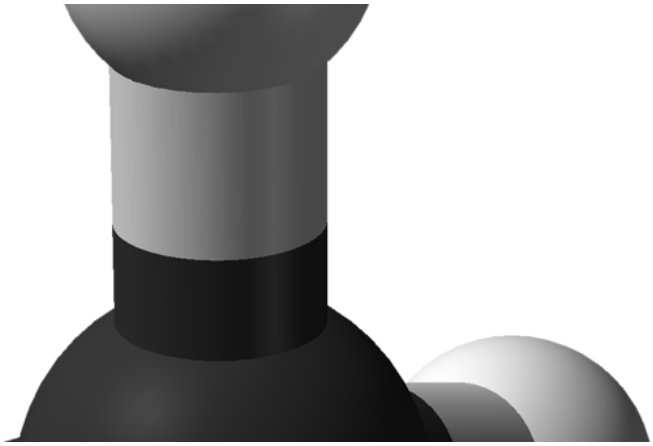

Ball and stick model of methane. Credit: Ben Mills/Public Domain

(Phys.org)—A team of researchers from the Paul Scherrer Institut and ETH Zurich, both in Switzerland, has developed a one-step process that uses water to convert methane to methanol. In their paper published in the journal *Science*, the group describes their technique, noting that in addition to offering a simple and relatively cheap way to make methanol, the only other byproduct is hydrogen.

Methane has been identified as a greenhouse gas, one that is perhaps more of a problem even than carbon dioxide because it traps more heat (some studies have suggested 25 times as much)—fortunately, not nearly

as much of it is emitted by humans into the atmosphere. It makes its way into the atmosphere due to animal flatulence and some industrial processes. It is also a byproduct at gas wells, where it is generally burned.

Methanol, on the other hand, has been considered a good alternative to gasoline for use in automobile engines. It is currently made using a variety of techniques and basic materials including coal, natural gas and even municipal waste. One approach is to use high-pressure and high-temperature oxidation of the gas, but most consider such methods too technically challenging to use in places such as drilling sites. In this new effort, the researchers describe a simpler way to make methanol using water (as an oxidant instead of oxygen) and methane.

In their process, water is used to oxidize methane over a bed of copper containing zeolite—the unique structure of the mineral lets the water behave as an oxidant. The team claims the process is 97 percent efficient, emitting only methanol and hydrogen. The method, the researchers note, is simple and easy enough that it could be used at drilling sites and the resulting methanol could be used as a liquid fuel or as an ingredient in making resins or plastics. The hydrogen could be used in any number of ways, including in fuel cells.

The researchers acknowledge that their work was a proof-of-concept study, which means that it is still not clear if their technique could be modified to convert methane on a very large scale in a cost-efficient manner.

More information: Vitaly L. Sushkevich et al. Selective anaerobic oxidation of methane enables direct synthesis of methanol, *Science* (2017). DOI: 10.1126/science.aam9035

Abstract
Direct functionalization of methane in natural gas remains a key

challenge. We present a direct stepwise method for converting methane into methanol with high selectivity (~97%) over a copper-containing zeolite, based on partial oxidation with water. The activation in helium at 673 kelvin (K), followed by consecutive catalyst exposures to 7 bars of methane and then water at 473 K, consistently produced 0.204 mole of CH3OH per mole of copper in zeolite. Isotopic labeling confirmed water as the source of oxygen to regenerate the zeolite active centers and renders methanol desorption energetically favorable. On the basis of in situ x-ray absorption spectroscopy, infrared spectroscopy, and density functional theory calculations, we propose a mechanism involving methane oxidation at CuII oxide active centers, followed by CuI reoxidation by water with concurrent formation of hydrogen.