

Using methane rather than flaring it

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Large amounts of methane worldwide are currently simply burnt - here on a oil rig. Credit: Colourbox/ETH Zurich

Chemists at ETH Zurich and the Paul Scherrer Institute have found a new, direct way to convert gaseous methane into liquid methanol. This offers industry the interesting prospect of using the gas, rather than simply burning it off, as is currently the case.

Methane is an abundant and inexpensive gas. Although it would be a suitable energy source and base material for the chemical industry, huge quantities of it are simply burnt off around the world - above all at [oil](#)

[fields](#) and refineries. "On satellite images of Earth at night, the Middle East is brightly illuminated. This is not because the region has an especially high number of large, brightly lit settlements, but rather because of methane flaring at the oil fields," says Jeroen van Bokhoven, Professor for Heterogeneous Catalysis at ETH Zurich and Head of the Laboratory for Catalysis and Sustainable Chemistry at the Paul Scherrer Institute (PSI).

Another reason for this wasteful approach to methane is that, at present, it is not sufficiently profitable to convert the gas into [methanol](#) in liquid form, which is easier to transport and more reactive. On the industrial scale, this conversion is currently performed using an indirect, elaborate and energy-intensive method that involves the production of syngas as an intermediate step.

The stuff of many chemists' dreams

"Many chemists consider the easy, direct conversion of methane into methanol as a dream reaction," says van Bokhoven. He and his team have demonstrated a new approach to this in a recent study. The world of industry is also very interested in better utilising this abundant, inexpensive raw material, says the catalysis researcher. Rising global production of shale gas is resulting in the release of ever-greater volumes of methane.

In theoretical terms, at least, it is already possible to convert methane into methanol. This is achieved using crystalline, copper-containing silicon aluminium compounds (zeolites) as catalysts. The process involved is cyclical and is conducted at various temperatures: activating the catalyst requires very [high temperatures](#), often up to 450 degrees Celsius. However, the actual reaction between methane and oxygen to form methanol cannot be carried out at temperatures significantly higher than 200 degrees, as otherwise any methanol formed would burn off

immediately. The reaction vessel must therefore be heated and cooled repeatedly, which is why this approach has never made it out of the research lab and into industry.

High pressure instead of high temperatures

However, van Bokhoven and his colleagues have now demonstrated that this reaction cycle can also take place at a constant temperature of 200 degrees. They achieved this through a clever trick, using methane at a far higher pressure: 36 bars instead of under 1 bar, as previously used.

"Working at a constant temperature makes this a much easier process to implement in industry," says Patrick Tomkins, Master student in van Bokhoven's group and first author of the current study.

Through analysis using X-ray absorption spectroscopy, the researchers were also able to show that, at the atomic level, the catalysed reaction in the new low-temperature/high-pressure method does not take place at the same position as it did in the existing high-temperature method. "As a result of the high pressure, different active centres are utilised in the copper zeolites," says van Bokhoven.

The new approach is not yet suitable for direct application in industry, van Bokhoven makes clear, as the yield is not yet sufficient for industrial purposes. However, the approach opens up a new range of possibilities. "In the past, catalysis scientists focused their research on copper zeolites for this reaction, because these are the most successful option in the high-temperature method. We also used these copper zeolites for the current study."

However, as the high-pressure method is catalysed differently at the atomic level, it is now worth investigating different catalysts, including those that haven't been considered at all so far, says van Bokhoven. These might be even better suited to the high-pressure method. This is

precisely what the catalysis researcher and his colleagues will work on in their future research, with a view to developing their own easy, direct and efficient process for converting [methane](#) into methanol - a dream come true for both the scientific community and the world of industry.

More information: Patrick Tomkins et al. Isothermal Cyclic Conversion of Methane into Methanol over Copper-Exchanged Zeolite at Low Temperature, *Angewandte Chemie International Edition* (2016). [DOI: 10.1002/anie.201511065](https://doi.org/10.1002/anie.201511065)

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