New Catalyst has Potential to Change Industrial Processes

Worried about gas prices? A new technology may help by making methanol, a viable fuel source for consumer cars, cheaper to produce.

A group of researchers including chemical engineer Meenesh Singh at the University of Illinois at Chicago have created a catalyst—a substance that increases the efficiency of a chemical reaction—that helps produce methanol from methane, a byproduct of coal mining. Industrial uses for methanol include fuel for both consumer cars and race cars. Conventionally, methane is transformed into methanol via a chemical reaction that requires a temperature of 300-700° C to initiate, making the process energy-intensive and economically unviable.

Singh's team optimized the process by creating a copper-titanium catalyst that binds to methane and allows the reaction to occur at 25° C, just a little over room temperature. The group's results were published in the February 23rd edition of *Proceedings of the National Academy of Sciences of the United States of America.*

The copper-titanium catalyst streamlines the procedure in two ways. In the first step of the conversion process, intense heat—usually in the form of steam—breaks a hydrogen molecule (H) off of methane (CH_4) to create a methyl group (CH_3). This is where titanium comes into play: the titanium in the catalyst reduces the temperature and energy required to break the hydrogen molecule off of methane. Once that occurs, hydroxide (OH) bonds with methane to create methanol (CH_3OH). However, the methanol does not last; seconds after creation, methanol breaks down into carbon dioxide (CO_2).

Singh's team solved this problem by introducing copper. Copper helps the methanol remain in a stable state long enough to be harvested. "The combination of these two catalysts is a game changer in this area of room temperature conversion of methane to methanol," Singh says.

The researchers tested catalysts made with 12 different transition metals, elements with properties similar to copper. The catalysts were compared by how much methanol the reaction produced when each one was used. Copper was the most efficient metal: the copper-titanium catalyst has a faradaic efficiency of 6% when used at 25° C, meaning that 6% of the product from the reaction is methanol.

This is significant; previous catalyst designs have been unable to reach this efficiency at temperatures low enough to attract industrial interest. Singh's catalyst is able to produce methanol at room temperature. He believes this key difference makes it possible to utilize his catalyst commercially.

Another advantage of the copper-titanium catalyst is its affordability. Singh says, “Titanium and copper are pretty inexpensive. They're not a rare element like silver [or] gold.” He expects utilizing his catalyst “should have similar economic considerations” compared to current methods of fuel production.

There is excitement that the technology could become even better. Golam Kibria, a chemical engineer at the University of Calgary, speculates that a catalyst with three metals would be effective. He says, “You probably need a catalyst with triple metals, where each one will function differently.” Kibria believes there is ample opportunity to improve upon Singh’s catalyst.

Currently, most methane procured from coal mining is wasted. Singh’s technology provides a tempting alternative to that reality. Over the next couple of years, Singh hopes to see his catalyst implemented into industrial processes.