ICFO

Turning pollution into potential

Groundbreaking new method enables sustained production of methane from carbon dioxide, advancing sustainable fuel development.

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Carbon dioxide (CO2) is one of the world's most abundant pollutants and a key driver of climate change. To mitigate its impact, researchers around the world are exploring ways to capture CO2 from the atmosphere and transform it into valuable products, such as clea fuels or plastics. While the idea holds great promise, turning it into reality - at least at a larg scale - remains a scientific challenge

A new study led by Queen's University (Canada), with the collaboration of ICFO researchers **Dr. Viktoria Golovanova** and **Prof. F. Pelayo Garcia de Arquer**, paves the way to practical applications of carbon conversion technologies and may reshape how we design future carbon conversion systems. The groundbreaking research addresses one of the main roadblocks in the carbon conversion process: catalyst stability.

In chemical engineering, a catalyst is a substance that accelerates a reaction - ideally, without being consumed in the process. In the case of carbon conversion, catalysts play a critical role by enabling the transformation of CO? into useful products such as fuels and building blocks for sustainable materials.

Copper-based materials are the most efficient catalysts for converting CO2 into methane, th main component of the natural gas used in water and home heaters, and for electricit generation. However, these copper catalysts undergo significant transformation in th process, and keeping the system working for a long period of time remains criticall challenging

The team has developed an innovative method to synthesize and recycle the copper catalys during the electrochemical reaction within the carbon conversion system. These exciti g results were recently published in Nature Energy.?

In this approach, what is added to the system is not the copper catalyst per se, but a catalys precursor (a substance that requires activation to become an active catalyst). Researcher then use electric signals to dynamically form catalysts in situ during the CO2 conversio process

What's better: when electric signals are turned off, the catalyst goes back to its precurso form. i¿½Repeating this cycle ensures selective and stable performance over exten ed periods. This is one of the most stable systems for carbon conversion to datei¿½, say Dr. Dinh, lead author of the study from Queen's Univer ity. In traditional carbon conversion systems, once the CO2 reduction reaction gets started, it needs to keep running to avoid catalyst degradation. But in the new system, when the reaction stops, the catalyst turns back into its precursor form. Once the system is turned back on, in a matter of seconds, it produces new catalyst and restarts the carbon reduction reaction.

"Our role was to visualize the catalyst surface using scanning electron microscopy, which revealed how its structure evolves during operation,i¿½ shares Viktoria Golovanova, talki g about ICFO's contribution to the study. i¿½Together with the team, we helped interpret t ese results and discuss how the recoverable strategy enables the catalyst to remain stable and efficient during long-term u e." Stability during intermittent operations is crucial for integrating carbon conversion sys ems and intermittent renewable energy sources, like solar or wind power. Dr. Dinh and team are energized about the new possibilities these findings present, especially for the productio of meth ne. As a next step, Dr. Dinh's lab will attempt to apply this same process to produce ethyl ne, ethanol, and other products. The team will also work to scale up the technology to prepar it for practical applications, paving the way for a more sustainable fut

Reference:

Gao, G., Khiarak, B.N., Liu, H. et al. Recoverable operation strategy for selective and stabl electrochemical carbon dioxide reduction to methane.Nat Energy (2025).

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