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Lock and stock: a new coating enables efficient CO₂ conversion into useful chemicals

Carbon dioxide (CO₂) is widely known as one of the most common greenhouse gases. While it is natural and beneficial in moderate amounts, human activities have increased its atmospheric concentration to the point of causing global warming and endangering life on Earth. Several actions have been proposed to reduce it and, even better, to convert it into useful chemicals. In this way, we could both take advantage of the CO₂ surplus and mitigate the greenhouse effect.

ICFO researchers have now designed a special coating for the electrodes used in the conversion of CO₂ into ethylene, ethanol, and other compounds with industrial and energy-related purposes. The coating was designed to remain effective even under challenging acidic conditions, which are essential for preventing the spontaneous loss of CO₂ into undesired products. The team has reported in the *Journal of American Chemical Society* substantial improvements in the production of desired chemicals compared to traditional approaches, presenting a new path toward CO₂ utilization technologies.

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A promising path to mitigate and eventually revert greenhouse effects associated to carbon emissions and global warming is the capture and **conversion of CO₂ into useful** products. CO₂ electroreduction enables the generation of specially appealing chemicals such as [ethylene](#) (the world most produced organic compound, used as a precursor in the [polymer](#) industry) and [ethanol](#) ([which can be readily used as a fuel and incorporated into existing supply chains](#)).

Obtaining these multicarbon products at high rates was recently achieved through CO₂ electroreduction in neutral and basic media. Unfortunately, this came together with a strong intrinsic limitation. Most of the CO₂ spontaneously reacted with hydroxyl species and was lost into unwanted carbonate, making the process more expensive and harder to scale up. While CO₂ reduction in acidic environments is an alternative, such proton rich environment

brings a different challenge: the more protons (H⁺) available, the easier the byproduct hydrogen (H₂) is produced, consuming electricity that should be destined to convert CO₂ into multicarbons instead.

To address this, researchers at ICFO, **Dr. Barbara Polesso, Adrian Pinilla-Sanchez, Dr. Eman H. Ahmed, Dr. Anku Guha, Dr. Marinos Dimitropoulos, Blanca Belsa, Dr. Viktoria Golovanova, Dr. Lu Xia, Ranit Ram, Dr. Sunil Kadam, Aparna M. Das, Dr. Junmei Chen, Dr. Johann Osmond, Adam Radek Martinez**, led by **Prof. at ICFO F. Pelayo Garcia de Arquer**, together with the Center for Nanophotonics from the University of Amsterdam (AMOLF), have developed a special polymeric coating for the [electrodes](#), reported in the Journal of American Chemical Society, which modulates the chemical environment to facilitate the CO₂ reduction process.?

At the beginning, the researchers tried to work with a well-studied material, a ionomer, an found that its structure (and hence function) was deteriorated with increasing acidity. Base on this insight, they designed a strategy to *lock* its structure and chemical function down to very acidic conditions. By incorporating a special type of polymer with a branched structure and an amine function, they finally stabilized the original ionomer. Additionally the resulting polyionomer **regulated proton activity**, offering a handle to suppress the creation of hydrogen gas, and **stabilized reaction intermediates**, which is essential to produce ethylene, ethanol, and related compounds. ?

The polyionomer was then implemented in a flow-cell electrode, leading to promising results. The team recorded an improvement of almost 30% in the generation of multicarbon product and 35% in the utilization of carbon atoms compared to the traditional approaches. **Thus, the study marks a promising step toward ultimately turning CO₂'s damage into an ally.**

References:

Polesso, et. al., Chemostructurally Stable Polyionomer Coatings Regulate Proton-Intermediate Landscape in Acidic CO₂ Electrolysis, J. Am. Chem. Soc. 2025, 147, 27278-27288.

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