Breakthrough in Artificial Photosynthesis Converts CO2 Into Ethylene

Posted by Okachinepa 09/30/2024

Courtesy of SynEvol
Credit: Silvia Cardarelli, Electrical and Computer Engineering, University of Michigan

Reusing CO_2 to create sustainable energy requires the ability to bind carbon atoms together. Now, scientists at the University of Michigan have created an artificial photosynthesis system that exhibits previously unheard-of levels of performance in binding two of them into hydrocarbons.

This innovative method outperforms previous artificial photosynthesis systems in terms of efficiency, yield, and lifetime when producing ethylene. Since ethylene is a hydrocarbon that is frequently used to make plastics, the system's direct usage would be to collect carbon dioxide that would otherwise be released into the atmosphere so that plastic might be made.

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Zetian Mi, an electrical and computer engineering professor at the University of Michigan and the study's corresponding author, said, "The performance, or the activity and stability, is about five to six times better than what is typically reported for solar energy or light-driven carbon dioxide reduction to ethylene."

The world's most produced organic chemical is really ethylene. However, it is usually made using gas and oil at high pressures and temperatures, which releases carbon dioxide.

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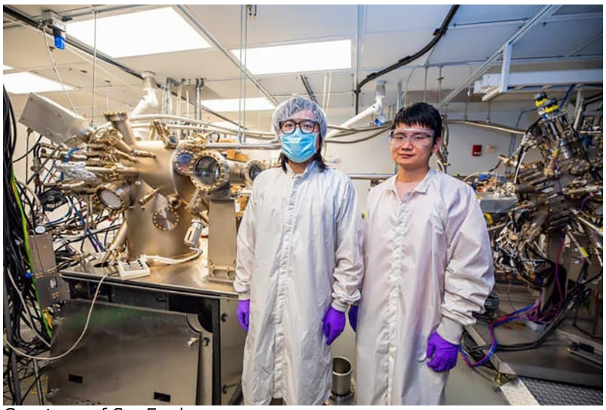
Longer chains of carbon and hydrogen atoms are what's being aimed for in order to create transportable liquid fuels. Eliminating all of the oxygen from water, or H2O, the hydrogen source, and CO2, the carbon source, is a portion of the task.

A forest of gallium nitride nanowires, each only 50 nanometers (a few hundred atoms) broad, and the silicon base on which they were grown are the two types of semiconductors that the device uses to absorb light. Copper clusters, each containing roughly thirty atoms, are scattered throughout the nanowires, where the reaction that converts carbon dioxide and water into ethylene occurs.



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The nanowires are exposed to light equal to that of the sun at noon while submerged in carbon dioxide-enriched water. The light's energy releases electrons that cause the water close to the gallium nitride nanowires' surface to split. In addition to producing hydrogen for the ethylene synthesis, this also produces oxygen, which the gallium nitride absorbs to form gallium nitride oxide.

Copper has the ability to cling to hydrogen and seize the carbon atoms in carbon dioxide, converting them into carbon monoxide. The researchers think that two carbon monoxide molecules link with the hydrogen when it is combined with the hydrogen and receives an energy boost from the light. It is thought that the reaction is finished at the interface where the three hydrogen atoms from splitting water replace the two oxygen atoms at the copper and gallium nitride oxide.

The researchers discovered that 61 percent of the free electrons produced by the light-emitting semiconductors aided in the production of ethylene. Although a separate catalyst based on silver and copper was able to attain an efficiency of approximately 50%, it was only able to operate for a few hours before degrading, and it need to run in a carbon-based fluid. The Michigan team's equipment, on the other hand, operated without slowing down for 116 hours, and they have operated comparable devices for 3,000 hours.

The fact that oxygen enhances the catalyst and permits a self-healing process is partly responsible for this, as gallium nitride and the water splitting process work in concert. In subsequent research, the device's endurance limits will be investigated.

In the end, the apparatus generated ethylene at a rate that was more than four times greater than that of the closest rival systems.

The paper's first author and assistant research scientist in electrical and computer engineering at the University of Michigan, Bingxing Zhang, stated, "In the future, we want to produce some other multicarbon compounds such as propanol with three carbons or liquid products."

Mi's ultimate goal is liquid fuels, which have the potential to make many of the current transportation technologies sustainable.