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Ionic liquid catalyst helps turn emissions into fuel

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This image shows biofuel production (left) compared to fuel produced via artificial synthesis. Crops takes in CO2, water and sunlight to create biomass, which then is transferred to a refinery to create fuel. In the artificial photosynthesis route, a solar collector or windmill collects energy that powers an electrolyzer, which converts CO2 to a synthesis gas that is piped to a refinery to create fuel. Credit: Image courtesy of Dioxide Materials

An Illinois research team has succeeded in overcoming one major obstacle to a promising technology that simultaneously reduces atmospheric carbon dioxide and produces fuel.

University of Illinois chemical and biomolecular engineering professor Paul Kenis and his research group joined forces with researchers at Dioxide Materials, a startup company, to produce a catalyst that improves artificial photosynthesis. The company, in the university Research Park, was founded by retired chemical engineering professor Richard Masel. The team reported their results in the journal *Science*.

Artificial photosynthesis is the process of converting carbon dioxide gas into useful carbon-based chemicals, most notably fuel or other compounds usually derived from petroleum, as an alternative to extracting them from biomass.

In plants, photosynthesis uses solar energy to convert carbon dioxide (CO2) and water to sugars and other hydrocarbons. Biofuels are refined from sugars extracted from crops such as corn. However, in artificial photosynthesis, an electrochemical cell uses energy from a solar collector or a wind turbine to convert CO2 to simple carbon fuels such as formic acid or methanol, which are further refined to make ethanol and other fuels.

"The key advantage is that there is no competition with the food supply," said Masel, a co-principal investigator of the paper and CEO of Dioxide Materials, "and it is a lot cheaper to transmit electricity than it is to ship biomass to a refinery."

However, one big hurdle has kept artificial photosynthesis from vaulting into the mainstream: The first step to making fuel, turning carbon dioxide into carbon monoxide, is too energy intensive. It requires so much electricity to drive this first reaction that more energy is used to produce the fuel than can be stored in the fuel.

The Illinois group used a novel approach involving an ionic liquid to catalyze the reaction, greatly reducing the energy required to drive the process. The ionic liquids stabilize the intermediates in the reaction so that less electricity is needed to complete the conversion.

The researchers used an electrochemical cell as a flow reactor, separating the gaseous CO2 input and oxygen output from the liquid electrolyte catalyst with gas-diffusion electrodes. The cell design allowed the researchers to fine-tune the composition of the electrolyte stream to improve reaction kinetics, including adding ionic liquids as a co-catalyst.

"It lowers the overpotential for CO2 reduction tremendously," said Kenis, who is also a professor of mechanical science and engineering and affiliated with the Beckman Institute for Advanced Science and Technology. "Therefore, a much lower potential has to be applied. Applying a much lower potential corresponds to consuming less energy to drive the process."

Next, the researchers hope to tackle the problem of throughput. To make their technology useful for commercial applications, they need to speed up the reaction and maximize conversion.

"More work is needed, but this research brings us a significant step closer to reducing our dependence on fossil fuels while simultaneously reducing CO_2 emissions that are linked to unwanted climate change," Kenis said.

More information: The paper, "Ionic Liquid - Mediated Selective Conversion of CO_2 to CO at Low Overpotentials," is available online at www.sciencemag.org/content/ear … 9/28/science.1209786

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