NREL Produces Ethylene Via Photosynthesis; Breakthrough Offers Cleaner Alternative for Transportation Fuels

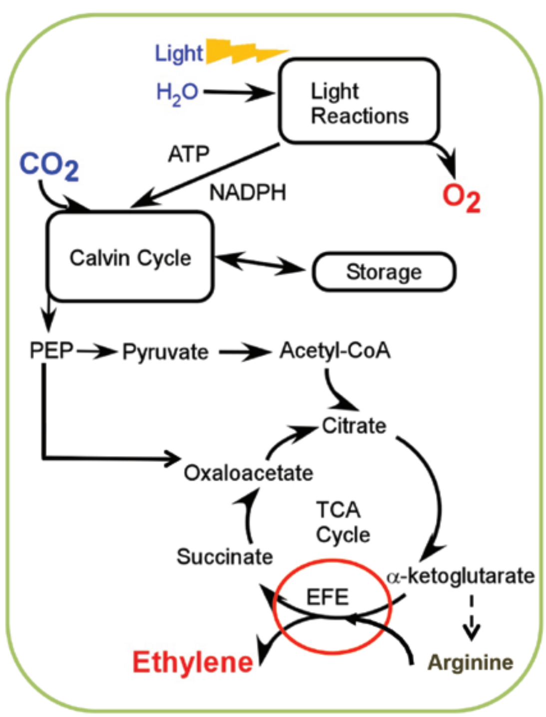
Ethylene is the most widely produced petrochemical feedstock in the world, and it currently is produced commercially only from fossil fuels, resulting in significant greenhouse gas emissions. But scientists at the National Renewable Energy Laboratory (NREL) have demonstrated a way to produce ethylene through photosynthesis, a breakthrough that could lead to more environmentally friendly ways to produce a variety of materials, chemicals, and transportation fuels.

The NREL scientists introduced a gene into a cyanobacterium and demonstrated that the organism remains stable through at least four generations, producing ethylene gas that can be easily captured. In the laboratory, the organism, *Synechocystis* sp. PCC 6803, produced 720 milligrams of ethylene per liter each day, a higher rate than those reported for microorganisms producing ethanol, butanol, or algae-based biofuels.

The traditional approach to producing ethylene—an essential ingredient in making plastics and industrial chemicals—is to use steam to break down long hydrocarbon chains. The process generates 1.5–3 tons of carbon dioxide for every ton of ethylene produced.

By contrast, in the NREL approach, carbon dioxide is food for the bacteria. The process does not release carbon dioxide into the atmosphere; in fact the organism uses the gas as part of its metabolic cycle. That could mean a savings of 6 tons of carbon dioxide emissions for every ton of ethylene produced—the 3 tons that would be emitted by tapping fossil fuels and another 3 tons absorbed by the bacteria.

Ten years ago, a group of Japanese scientists was the first to try to produce ethylene via photosynthetic conversion in the cyanobacterium *Synechococcus* 7942. But by the fourth generation, the bacteria were defunct, producing no ethylene at all.



NREL turned to a different cyanobacterium, *Synechocystis* 6803, which scientists had been researching for a long time, knowing how to change its DNA sequences. They manipulated the sequence to design an ethylene-producing gene that is more stable and more active than the original version.

This process resulted in an organism that uses carbon dioxide and water to produce ethylene, but doesn't lose its ability to produce ethylene over time.

This graphic shows the metabolic pathway for photosynthetic ethylene production in a genetically engineered cyanobacterium. EFE stands for ethylene forming enzyme and is the key step for enabling ethylene production from cyanobacteria.

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Quick Facts

NREL scientists have introduced a gene into a bacterium, *Synechocystis* sp. PCC 6803, that spurred it to produce ethylene gas at a fast rate while remaining stable for at least four generations.

The NREL scientists had used *Synechocystis* sp. PCC 6803 in other biofuel experiments, so they knew how to achieve results by manipulating the bacterium's genes.

The traditional approach to manufacturing ethylene creates up to 3 tons of carbon dioxide for every ton of ethylene produced.

The photosynthetic approach to producing ethylene can potentially avoid the release of 6 tons of carbon dioxide gas into the atmosphere for every ton of ethylene produced.

In the NREL approach, the ethylene separates from the culture medium and rises to the top of the photobioreactor for easy collection—much easier than the complex separation needed for fuels such as ethanol.

NREL is in discussions with potential industry partners.

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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