NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Produces Ethylene via Photosynthesis

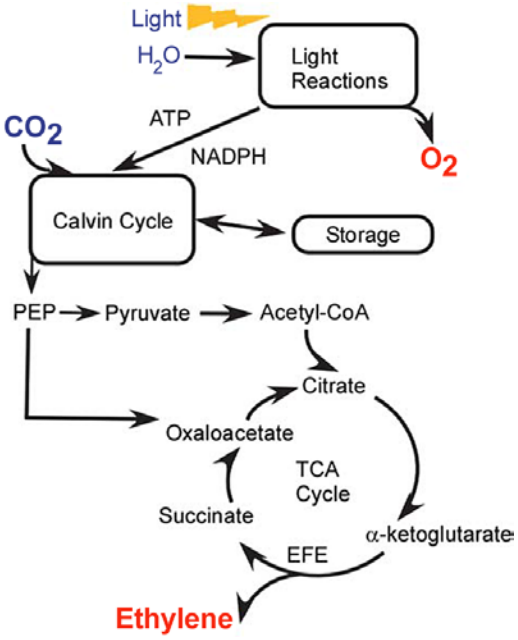
Highlights in Science

Environmentally friendly process offers intriguing alternative to fossil-fuel-based ethylene for chemicals and transportation fuels.

Scientists at the National Renewable Energy Laboratory (NREL) have demonstrated a new way to use photosynthesis to produce ethylene. NREL scientists introduced a gene for ethylene forming enzyme (EFE) into a cyanobacterium and demonstrated that the organism remained stable through at least four generations, producing ethylene gas that could be easily captured.

Ethylene is the most widely produced petrochemical feedstock in the world. It is currently produced exclusively from fossil fuels, and its production is the largest carbon dioxide (CO_2)-emitting process in the chemical industry. Steam cracking of long-chain hydrocarbons from petroleum produces 1.5 to 3 tons of CO_2 for every ton of ethylene produced.

The NREL process, by contrast, does not release CO_2 into the atmosphere. Conversely, the process recycles CO_2, as the organism — *Synechocystis* sp. PCC 6803 — utilizes the gas as the carbon source for making ethylene. This could mean a savings of six tons of CO_2 emissions for every ton of ethylene produced — the three tons that would be emitted using fossil fuels and another three tons absorbed by the bacteria.



The pathway for ethylene production in the unicellular cyanobacterium Synechocystis *sp. PCC 6803.*
Illustration by Jianping Yu and Justin Ungerer, NREL

Synechocystis produced ethylene at a sustained rate and is still being improved. The laboratory-demonstrated rate of 170 milligrams of ethylene per liter per day is greater than the rates reported for the photosynthetic production of other algal biofuels.

NREL is initiating discussions with potential industry partners to help move the process to commercial scale. Interested companies include those in the business of producing ethylene or transportation fuels, as well as firms that build photobioreactors.

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Reference: Ungerer, J.; Tao, L.; Davis, M.; Ghirardi, M.; Maness, P.-C.; Yu, J. (2012). "Sustained photosynthetic conversion of CO_2 to ethylene in recombinant cyanobacterium *Synechocystis* 6803." *Energy & Environmental Science* (5:10); pp. 8998–9006.

Key Research Results

Achievement

NREL scientists have demonstrated a new way to use photosynthesis to produce ethylene.

Key Result

Bio-ethylene does not suffer from many of the technical difficulties that are associated with the production of other biofuels, making bio-ethylene an attractive alternative to petroleum and an effective way to reduce CO_2 emissions.

Potential Impact

This breakthrough could change the way materials, chemicals, and transportation fuels are made, and help clean the air.

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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