NREL
NATIONAL RENEWABLE ENERGY LABORATORY

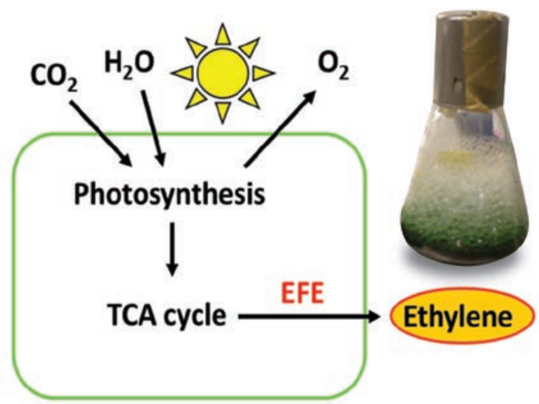
NREL's Cyanobacteria Engineering Shortens Biofuel Production Process, Captures CO_2

Highlights in Research & Development

The flexibility of cyanobacterial metabolism supports direct conversion of carbon dioxide (CO_2) to ethylene.

Photosynthesis fuels growth in plants and algae, two of the primary components of biomass. Biomass, in turn, can be converted into various fuels and chemicals.

NREL researchers have shortened this process by engineering one photosynthetic organism, cyanobacterium, so that it converts CO_2 directly into the target chemical ethylene, bypassing the biomass production and processing stage. Ethylene is the most widely produced petrochemical feedstock in the world and is currently produced from fossil fuels; this method of producing ethylene is the chemical industry's largest emitter of CO_2.



Photosynthetic ethylene production by engineered cyanobacteria. Illustration and photo by Jianping Yu, NREL.

The NREL research team improved ethylene productivity using engineered cyanobacteria so that up to 10% of photosynthetically fixed carbons become ethylene. This capability could mean a savings of six tons of CO_2 emissions for every ton of ethylene produced. The CO_2 savings include the three tons that would be emitted by tapping fossil fuels and another three tons absorbed by the bacteria.

The project also brought an unexpected yet welcome surprise. The chemical reactions (cellular metabolism) that occur in cyanobacteria were expected to change the rate of cell growth, possibly inhibiting it because of significant and continuous loss of carbon. Yet growth appears to be unaffected.

NREL developed analytical methods to learn how these cells adapt to loss of carbon and maintain their growth rate. Experimental data and the derived metabolic models showed dramatic changes of carbon flow associated with ethylene production. The cells were able to fully compensate for the carbon loss by boosting photosynthesis and increasing their carbon fixation rate—the process of converting CO_2 to organic compounds. Therefore, this new process has two advantages: the cyanobacteria not only produce ethylene and emit less CO_2 compared to the traditional process, they actually capture more CO_2 as well.

Technical Contact: Jianping Yu, Jianping.Yu@nrel.gov

References: Xiong, W.; Morgan, J.A.; Ungerer, J.; Wang, B.; Maness, P-C.; Yu, J. "The plasticity of cyanobacterial metabolism supports direct CO_2 conversion to ethylene." Nature Plants, April 27, 2015. DOI: 10.1038/NPLANTS.2015.53.

Key Research Results

Achievement

Researchers engineered cyanobacteria so that this photosynthetic organism converts CO_2 directly into ethylene.

Key Result

By eliminating the biomass stage of the process, the biofuels production industry can realize savings that result from a shorter production process and decreased time to market.

Potential Impact

The research indicates that using engineered cyanobacteria in the biofuels production process can avert tons of CO_2 emissions that would otherwise be released using the traditional process.

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.

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 | www.nrel.gov

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