NATIONAL RENEWABLE ENERGY LABORATORY

NREL Demonstrates Photocatalytic Conversion With Mutant Microbe

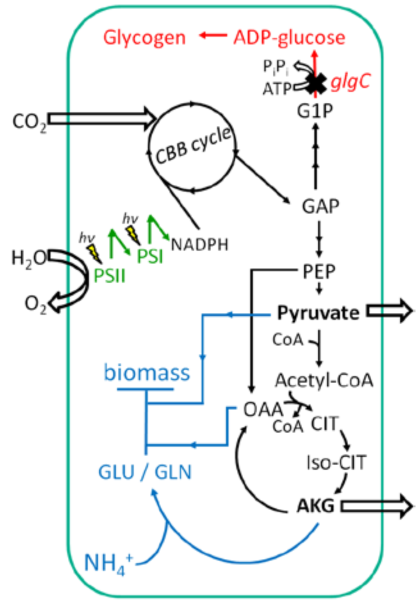
Highlights in Science

Breakthrough will facilitate future research on photosynthetic production of biofuels.

Oxygenic photosynthetic microbes (i.e., algae and cyanobacteria) have great potential to produce fuels from sunlight, water, and carbon dioxide. However, cellular growth competes with conversion of carbon dioxide (CO_2) into biofuels and necessitates disposal or recycling of biomass. A solution would be to arrest biomass accumulation, while simultaneously redirecting photosynthetically fixed carbon to products of interest.

Scientists at the National Renewable Energy Laboratory (NREL) have achieved a dramatic redirection of carbon allocation from biomass growth to organic acids excretion in a photosynthetic microbe blocked for glycogen synthesis.

NREL demonstrated that under nitrogen-depleted conditions, a mutant strain of the cyanobacterium *Synechocystis* sp. PCC 6803 does not accumulate cellular glycogen yet converts CO_2 to substantial amounts of organic acids. This was achieved by nitrogen depletion to limit growth and the mutation in glycogen synthesis to redirect metabolism. The organic acids excreted, pyruvate and alpha-ketoglutarate, are platform chemicals that are used for synthesis of many other organic compounds.



Metabolic scheme for Synechocystis *sp. PCC 6803 glycogen synthesis mutant cells (red arrows) under nitrogen-deprived conditions. Carbon (as CO_2) enters the Calvin–Benson–Bassham (CBB) cycle to produce metabolic intermediate carbon compounds (black arrows). In the absence of a nitrogen source, glutamate and glutamine (GLU/GLN) synthesis is halted, as is biomass accumulation (blue arrows). Two organic acids are excreted.*

This observation provides a novel system to study both solar bio-catalysis and regulation of photosynthetic carbon partitioning. This new tool will facilitate future research on photosynthetic production of biofuels and chemicals in addition to providing new insights into global regulatory mechanisms in cyanobacterial carbon allocation.

This discovery was funded by an NREL Laboratory Directed Research and Development grant. Follow-up study is being supported by the U.S. Department of Energy Office of Science, Office of Basic Energy Sciences.

Technical Contact: Jianping Yu, *jianping.yu@nrel.gov*

Reference: Carrieri, D.; Paddock, T.; Maness, P.-C.; Seibert, M.; Yu, J. (2012). "Photo-catalytic conversion of carbon dioxide to organic acids by a recombinant cyanobacterium incapable of glycogen storage," *Energy Environmental Science* (5); pp. 9457–9461.

Key Research Results

Achievement

NREL used a mutant strain of the cyanobacterium *Synechocystis* sp. PCC 6803 to demonstrate photocatalytic conversion.

Key Result

This strain provides a novel system to study solar bio-catalysis and regulation of photosynthetic carbon partitioning, and serves as a platform for de novo conversion of carbon dioxide to organic products.

Potential Impact

This new tool will facilitate future research on photosynthetic production of biofuels and chemicals in addition to providing new insights into global regulatory mechanisms in cyanobacterial carbon allocation.

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

NREL/FS-2700-58227 | May 2013

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.