NREL
NATIONAL RENEWABLE ENERGY LABORATORY

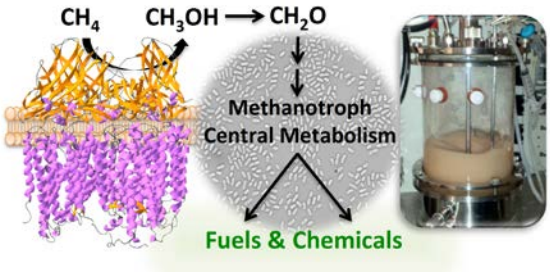
NREL Advancements in Methane Conversion Lead to Cleaner Air, Useful Products

Highlights in Research & Development

NREL research has developed an effective genetic engineering strategy that converts methane waste into valuable chemicals and transportation fuels.

Methane is the second most abundant greenhouse gas (GHG) after carbon dioxide, with nearly 60% of these emissions derived from human activity.[1] NREL researchers are exploring the microbial conversion of methane to value-added chemicals, such as lactate, using natural methane-consuming bacteria to capitalize on the squandered methane. This innovative solution both reduces GHG emissions and valorizes a high-volume, high-energy gas.

Until recently, biological methane conversion has been hindered by low productivity and the limited genetic tractability of natural methane-consuming microbes known as methanotrophs. Leveraging the recently identified, tractable bacterium *Methylomicrobium buryatense*, NREL researchers have facilitated the bioconversion of methane to lactate, a high-value platform chemical used in the production of bioplastics. This new route avoids competition with food substrates, such as corn, utilized in conventional sugar-based lactate production, and offers a potentially transformational path to simultaneous mitigation of GHG emissions and biological methane upgrading.



NREL researchers developed a method of bioconversion of methane to fuels and chemicals via engineered methanotrophic bacteria. Image by Calvin Henard, NREL

NREL researchers successfully demonstrated the conversion process via the development of a methanotroph expressing a heterologous *Lactobacillus* lactate dehydrogenase. The maximum lactate titer produced by the engineered methanotroph is an order of magnitude higher than those achieved for any previously reported engineered methanotrophic bioproduct. In addition, biomass-derived lipids from this process can be readily converted to biofuels, supporting the potential for concurrent methane biocatalysis to liquid fuels and platform chemicals.

This innovative research opens the door to developing an array of engineered, methane-converting bacteria and strategies that lead to "green" chemicals and fuels derived from methane, while also reducing GHG emissions.

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References: Henard, Calvin, Holly Smith, Nancy Dowe, Marina Kalyuzhnaya, Philip Pienkos, and Michael Guarnieri. "Bioconversion of methane to lactate by an obligate methanotrophic bacterium." *Scientific Reports* 6 (2016). doi:10.1038/srep21585.

[1] EPA. *Methane and Nitrous Oxide Emissions from Natural Sources*. Washington, DC: U.S. Environmental Protection Agency (EPA), 2010.

Key Research Results

Achievement

Researchers at NREL leveraged the recent on-site development of gas fermentation capabilities and novel genetic tools to directly convert methane to lactic acid using an engineered methanotrophic bacterium.

Key Result

The results provide proof-of-concept data for a gas-to-liquids bioprocess that concurrently produces fuels and chemicals from methane. NREL researchers developed genetic tools to express heterologous genes in methanotrophic organisms, which have historically been difficult to genetically engineer. Using these tools, researchers demonstrated microbial conversion of methane to lactate, a high-volume biochemical precursor predominantly utilized for the production of bioplastics.

Potential Impact

Methane biocatalysis offers a means to concurrently liquefy and upgrade natural gas and renewable biogas, enabling their utilization in conventional transportation and industrial manufacturing infrastructure. Producing chemicals and fuels from methane expands the suite of products currently generated from biorefineries, municipalities, and agricultural operations, with the potential to increase revenue and significantly reduce greenhouse gas emissions.

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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