Northeast GAS ASSOCIATION NYSEARCH

Technology Brief

Scaling of Microbial Power to Gas Conversion for Long Term Operation

Description: **Optimization of biological and chemical processes in the intermittent operation (periods of electron starvation) of microbial electromethanogenesis for power-to-gas operations**

Status: **Bioreactors have been successfully set up for laboratory testing and monitoring. Evaluating several biochemical properties of the active microbes during intermittent operation is ongoing.**

BENEFITS

As the natural gas industry is beginning to see a shift towards decarbonization, NYSEARCH has the opportunity to investigate an innovative energy storage solution and an unconventional method to create a renewable resource through microbial electromethanogenesis. There is a need and a business opportunity for long-term storage of electrical energy, especially as renewably produced energy becomes more abundant. Moreover, conversion of power to natural gas from CO_2 is an emerging platform for producing carbon-neutral methane, which also provides an important business opportunity. This research addresses for the first time the molecular, cellular and metabolic processes associated with a long-term operation of an electromethanogenic system; converting electrical energy plus CO_2 into methane at high rates. Furthermore, this innovative microbial power-to-gas platform provides the potential to produce methane that can be upgraded as renewable natural gas (RNG) and injected into existing infrastructure.

BACKGROUND

The development of new ways to store excess electrical energy and produce carbon-neutral biofuels is key to mitigating global climate change and developing a more sustainable society. Electricity, in particular electricity produced from renewables, is becoming a more abundant and common resource. However, electricity produced from renewables is intermittent and is inevitably lost when not used following production. A viable and long-term solution to store this excess renewable energy is needed. One desirable and promising path to store intermittent, renewable electrical energy is Power-to-Gas technology, where electricity is converted into methane or hydrogen, which is immediately compatible with today's energy infrastructure. Conventional power-to-gas technologies produce hydrogen or methane from electrochemical processes with technical limitations. Hydrogen, alone, is not an ideal chemical storage compound with low energy density and significant safety concerns for its use.

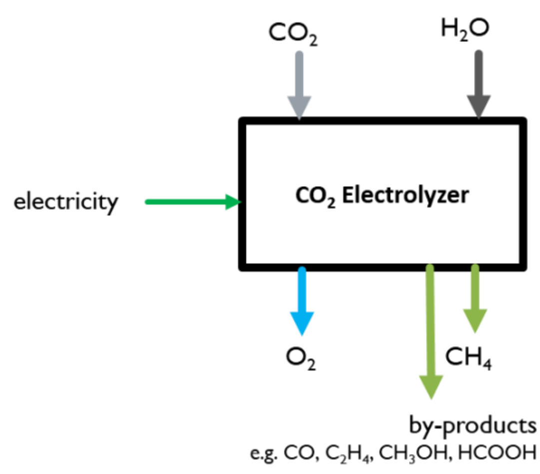

Figure 1. Traditional Power to Gas (P2G) process

Microbial electrosynthesis is emerging as a viable technology platform for converting electrical energy into natural gas by microbial reduction reactions at high selectivity and efficiency at the cathode.

The current state-of-the-art in microbial Power-to-Gas technology includes a traditional water electrolyzer that generates hydrogen which is then pumped into an anaerobic digestor to upgrade methane into biogas (see Figure 2). The cost and complexity of these electrolyzers represent severe technical and cost limitations.

Figure 2. SOA microbial P2G process

The basis of this project explores Stanford University's innovation where microbial electrosynthesis uses CO_2 as a substrate with a cathode created from low-cost sustainable metals and direct consumption of the produced hydrogen, providing a viable alternative beyond batteries for long-term and seasonal energy storage. The innovation of an integrated microbial power-to-gas conversion is that it is a carbon neutral process (uses atmospheric CO_2 as a substrate) and one where hydrogen gas does not need to be transferred as seen in the current state-of-the-art technology. This phenomenon significantly reduces capital and operating costs. Figure 3 summarizes this electromethanogenesis process.

TECHNICAL APPROACH

Stanford University's recent work on microbial electromethanogenesis provides the first molecular understanding of how microbes take up electrons from the cathode. They have demonstrated how a microbial electrosynthesis platform can be integrated with advanced catalysts to efficiently funnel electrons and enhances the conversion rate from power to gas.

Figure 3. Integrated electromethanogenesis process

NYSEARCH and Stanford are working to better understand the long-term effects that the microbes experience as living agents of electrochemical reactors. Specifically, this phase of research focuses on the response of the microbes to physical and chemical changes associated with intermittent operation of an integrated bio-electrochemical reactor. Stanford is investigating factors impacting performance during electron starvation (intermittency) such as microbial viability and longevity, recovery rate during intermittency, and cell protein expression.

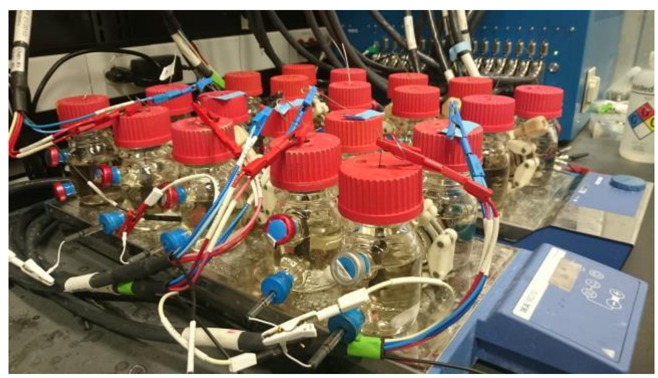

Figure 4. Laboratory set-up of electrochemical reactors prepared for long-term operation

PROGRAM STATUS

The research team is inoculating and testing the bioreactors under predictable and unpredictable intermittent patterns to evaluate microbial performance. With information on the chemical and biological changes associated with intermittency, NYSEARCH and Stanford are poised to develop an engineering prototype that is scalable for industry power-to-gas operations.

For more information contact:
admin@NYSEARCH.org