Microbial Electrosynthesis

Functionalizing an electrode through extracellular enzymes

July 21 2015

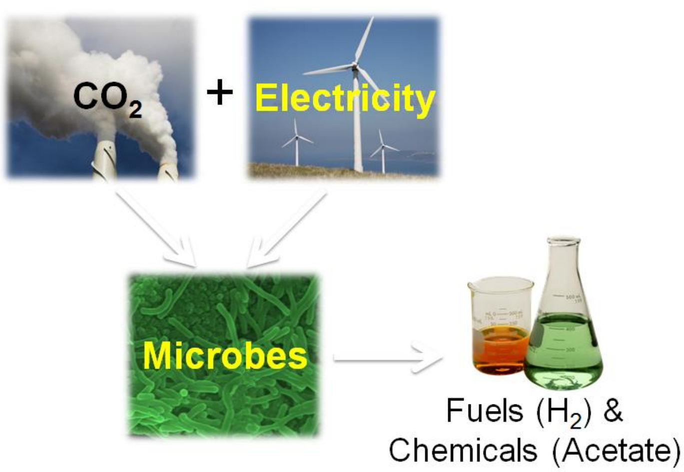
Yoel R. Cortes-Pena

Georgia Institute of Technology

Chemical Engineering Student

330-267-9635

Microbes are widely used in the biotechnology industry to synthesize a wide range of products including medicine, plastics, and dyes used in clothes. In a microbial electrosynthesis cell (MEC), microbes can also be used to synthesize fuels such as hydrogen and a valuable chemical called acetate from two simple inputs: electric current (an energy source) and carbon dioxide (a carbon source). Therefore, MECs have the ability to produce renewable fuel when coupled to solar or wind energy as the power source. The fuel is carbon neutral, meaning the *net* production of CO_2 into the atmosphere from burning this fuel is zero. This environmentally friendly technology has the potential to replace fossil fuels. Additionally, because the only requirements are CO_2 and a renewable energy source, countries would be able to produce their own fuel locally. The key step in microbial electrosynthesis is getting the electrons into the microorganisms. A new study at Dr. May's laboratory of environmental microbiology at the Medical University of South Carolina is testing how microbes may be releasing extracellular enzymes that support this process.



The schematic on the left shows the basic concept of microbial electrosyntesis. Microbes are able to consume waste CO_2 and electrical energy to produce fuels and chemicals. When the electricity source is renewable energy, then there is no net production of carbon dioxide. This process would ultimately allow the production of green, renewable fuel.

The microbes used at the May lab originates from South Carolina's very own Palmeto Brewery in Charleston. These microbes, however, were later selectively enriched for the optimal production of hydrogen fuel. The resulting microbiome is now trademarked as the Electrobiome™. The mechanism of how the Electrobiome "eats" electricity and drives the formation of fuel is not known. Dr. May has developed the hypothesis that extracellular enzymes may attach themselves to the electrode and directly uptake electrons to produce metabolites that serve as food for the microbes. This hypothesis is based on how certain metabolic enzymes such as hydrogenases and formate dehydrogenases (FDH) are capable of attaching themselves to an electrode and consume electrons to produce H_2 and formate. Both H_2 and formate serves as food for Acetobacterium, the dominating genus of the Electrobiome. “The end goal of bio-electrosynthesis is to produce fuel from renewable energy and CO_2. The key step of this process is getting electrons off the electrode. Extracellular enzymes such as hydrogenases may be driving this process and support the production of hydrogen in our reactors.” stated Dr. May stressing the importance of testing this hypothesis.

The Electrobiome originates from the Palmetto Brewery in Charleston, SC. By sustaining these bacteria in the microbial electrosynthesis cell environment, the microbes were selectively enriched to produce high levels of hydrogen and acetate. The composition of the microbes is dominated by Acetobaceterium, a genus known to consume H_2 *and* CO_2 *as substrate and produce acetate as a byproduct.*

Yoel Rene Cortes-Pena, an intern from the Georgia Institute of Technology took the first step to test this hypothesis by asking the question “Are active hydrogenases or FDH released from the microbes?” Active extracellular hydrogenases would suggest that they can bind to the cathode biofilm and remain active. Yoel withdrew a sample from a microbial electrosynthesis cell and used it to grow various cultures in anaerobic test tubes. Then, once the cells were ready to harvest, he centrifuged out the cells from the supernatant and tested the hydrogenase activity as well as the FDH activity in each fraction.

The results from this experiment can have several applications in the optimization MECs. For example, if a large amount of extracellular hydrogenase activity is seen, then a subsequent experiment would be to see whether enzyme extracts can increase fuel production in an MEC. On a higher level, understanding how the Electrobiome supports an MEC will allow researchers to transform and modify the Electrobiome to produce other fuels such as ethanol.

— ### —

For additional details about this project, visit blogreu.wordpress.com and www.youtube.com/user/yoelco

Yoel Rene Cortes-Pena
Georgia Institute of Technology
330-267-9635
yoelcortes@gmail.com

Dr. Harold May
Medical University of South Carolina
Hollings Marine Laboratory
mayh@musc.edu