BIO210 - Microbiology
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Utilizing Microorganisms to Improve Oil Extraction & Develop Alternative Fuel

Currently, the overwhelming of majority of scientists agree that global warming has been a product of human activity, more specifically the burning of fossil fuels for energy. By creating energy from unrenewable resources we are creating pollution and running out of those resources. With microbiology we could change our reliance on unclean energy. "However, the discipline has struggled for recognition in a world dominated by geophysicists and engineers' despite being widely known but still poorly understood" (1). The role of microbiology is even less understood in developing industries like fracking. It's becoming apparent that our best option to reduce emission and dependence on nonrenewable sources is by investing in innovative biotechnologies. Though, it would be difficult to drop fossil fuels all together. A good way to start the transition would be to take existing methods of energy production and improve them by means of microbiology.

For example, fracking (short for hydraulic fracturing) is a method used to release trapped methane gas that can be harnessed and used to produce energy. According to Kelly Wrighton, assistant professor of microbiology and biophysics at Ohio State, a new genus of bacteria has been found at fracking sites. After conducting experiments involving 2 different fracking wells over 328 days the researchers were surprised to find that "both wells […] developed nearly identical microbial communities" (2). These results surprised researchers due to the fact the wells were "more than a mile and a half below ground, were formed millions of years apart, and contained different forms of fossil fuel" (2).

The bacteria discovered are known as *Candidatus Frackibacter* and could be utilized in order to increase methane gas production. In addition to *Candidatus Frackibacter* the known microbe *Halanaerobium* was also found present. From examining genome of different microbes, researches uncovered that osmoprotectants were being eaten by *Halanaerobium* and *Candidatus Frackibacter*. In turn, these bacteria provided food for other microbes known as *methanogens*, which ultimately produce methane gas. The researchers validated their finding by growing those microbes in a lab setting. This method seems promising, and more research needs to be done in order to scale these microbes for real world application.

Contrary to fracking, an existing microbial solution that is already being utilized successfully in production is MEOR (Microbial enhanced oil recovery). It solves one of the biggest problems in oil production, getting all of it. When an oil well reaches a certain age, the cost of extracting the oil from deep underground eventually outweighs the amount of money generated by the oil. At that point the oil well is abandoned. MEOR however, can "push that tipping point further back than ever before, extending the productive life of oil reserves by as much as 11%" (3).

This is done by a "Three-Pronged Approach". The first method utilizes microorganisms to "break down crude oil [by] reducing its viscosity" (3). It's a lot easier to drive oil hundreds of feet upward if it flows more like water, rather than maple syrup. The second method is displacement of the oil. "As the microorganisms naturally metabolize, they produce carbon dioxide gas as well as biomass" (3). The carbon dioxide and biomass produced displaces the oil, pushing it upward. The third method is known as selective plugging. The Rock deep underground, from which oil is extracted from is "often porous, full of tiny holes into which oil can flow. Microorganisms are selected for their ability to produce exopolysaccharides" (3). Those microorganisms are essentially water proof and plug up the holes in the porous rock deep underground, leaving the oil nowhere to go but up. This "Three-Pronged Approach" can be improved upon by designing microorganisms that can best direct oil upward. To design such microorganisms will require genetic engineering to microorganisms that can already withstand extremely high temperatures.

Although, both fracking and MEOR could introduce many unknown consequences. The known consequences of fracking/MEOR include contaminating drinking water and causing earthquakes. What could be done to mitigate the contamination would be to develop microorganisms that can purify the contaminated water. This might be possible through an Archaea-based microbial fuel cell operating at high ionic strength conditions.

In a study done by Ximena C. Abrevaya, Natalia Sacco, Pablo J. D. Mauas, and Eduardo Cortón two archaea microorganisms (*Haloferax volcanii* and *Natrialba magadii*) were used as biocatalyst at a microbial fuel cell (MFC) anode. These archaea are halophiles that thrive in high salt concentrations. “A microbial fuel cell is a device that converts chemical energy stored in organic substances or other reduced compounds into electrical energy by using microorganisms as biocatalysts” (4).

The way MFC’s work can be broken down in to a 5-step process. In the first step bacteria decompose on the anode, freeing electrons H+ ions. In the second step electrons flow from the bacteria to the anode and can be assisted by a mediator to increase power output, in the case of this study the mediator is neutral red. In the third step, the electrons flow from the anode through a wire, where an electric potential difference is generated via electrochemistry, and to the cathode. Then the current generated in the wire can be used to perform work. The fourth step is where the freed H+ ions, from the first step, are able to flow through the semipermeable membrane to the cathode. Lastly in the fifth and final step, the electrons from the cathode combine with oxygen and the newly arrived H+ ions to purify and form pure H2O.

The “biofilms on the anode have been demonstrated to increase the current due to the direct electron transfer between the microbes and the surface of the anode” (5). Due to this MFCs are very efficient, do not rely on fossil fuels for energy, and can run effectively on sources like food waste and sewage. Currently, their main application is to produce electricity while simultaneously cleaning wastewater. It’s estimated that “domestic waste water contains 9.3 times the amount of energy used to treat wastewater through the standard aeration-based process in waste management plants” (5). MFC’s are proving to be a great starting point for developing self-sustaining waste purifying systems.

The study concluded that the halophilic archaea *H. volcanii* is an excellent biocatalyst for an archaea-based MFC due to it having a naturally low internal resistance. Perhaps in the future a similar method could be used to purify the contaminated waters caused by fracking and MEOR. Currently, it’s being looked into if this archaea-based MFC system could be used to purify brine water at reverse osmosis installations arounds the globe. Nonetheless, this system is already being used to purify wastewater and hopefully with time (and research) it can begin to unlock doors to a more sustainable world.

Works Cited

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