QUARTERLY PROGRESS REPORT

September 1 to November 31, 2009

PROJECT TITLE: Usage of Microbial Fuel Cell Technology to Prevent Iron Release nearby Landfills in Northwest Florida

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WORK ACCOMPLISHED DURING THIS REPORTING PERIOD:

Shewanella putrefaciens Culturing

In this research, we investigated iron release prevention and energy generation using mediator-less MCFs. These MFCs depend on the bacteria to transfer electrons to the anode. For this research, we used *Shewanella putrefaciens*, which are commonly found in sediments, especially in the iron rich Northwest Florida subsurface soil, in the MFC studies. We cultured electrochemically active *S. putrefaciens* using collected soil samples from Franklin County Landfill, Quincy-Byrd Landfill (Gadsden County), Baker Landfill (Okaloosa County), and Santa Rosa Central Landfill (Santa Rosa County) as the inocula. Soil samples were collected 1 to 3 feet below the surface, 100 to 300 feet away from the landfills. Continuous cultivation and enrichment were carried out in an anaerobic chamber after the samples were transported back to the laboratory. Specifically, 10 mg soil was transferred into a 250 ml serum bottle containing 100 ml sterilized culture media, which had a composition of KH_2PO_4, 160 mg/l; K_2HPO_4, 420 mg/l; Na_2HPO_4, 50 mg/l; NH_4Cl, 40 mg/l; $MgSO_4 \cdot 7H_2O$, 50 mg/l; $CaCl_2$, 50 mg/l; $FeCl_3 \cdot 6H_2O$, 0.5 mg/l; $MnSO_4 \cdot 4H_2O$, 0.05 mg/l; H_3BO_3, 0.1 mg/l; $ZnSO_4 \cdot 7H_2O$, 0.05 mg/l; $(NH4)_6Mo_7O_{24}$, 0.03 mg/l; glucose, 200 mg/l; and ammonia chloride, 60 mg/l. The pH of the media was adjusted to 7.4 with 1 M HCl or 1 M NaOH, after which the media was sterilized by autoclaving (121^oC and 1 atm) for 20 min. Glucose was filter-sterilized and aseptically added to the autoclaved media. The serum bottle was equipped with CO_2 entrapping devices and 1 M KOH was used to entrap CO_2. Resazurin (1 mg/l) was added as a redox indicator to indicate contamination by molecular oxygen and cysteine (3.0 g/l) was added to reduce the trace amount of oxygen remaining in the media after autoclaving. The headspace of the serum bottle was pressurized with ultra-pure nitrogen and the serum bottle was capped with butyl rubber septa and crimped with an aluminum seal. The inoculated serum bottle was put into a rotary-shaker (150 rpm at 35 ℃) in the dark for at least 1 week until the formation of black precipitate at the bottom and on

the wall of the serum bottle could be observed. Then 10 ml enriched culture was transferred into 100 ml fresh culture media with approximately 50 mg/l Fe^{3+} for the second phase culture enrichment. After the fourth phase enrichment was completed, bacterial cells were harvested by centrifugation (6000 *g*, 15 min) and washed twice with fresh, anoxic $NaHCO_3$ buffer (0.05 M) under an extra-pure nitrogen atmosphere. The concentrated cells was re-suspended in a serum bottle containing fresh, anoxic $NaHCO_3$ buffer (0.05 M) to give a final concentration of approximately 5×10^9 cells/ml. *S. putrefaciens* was identified by polymerase chain reaction (PCR) analysis.

Laboratory Scale MFC Experiments

Two dual-chamber MFCs, one batch MFC and one continuous MFC were constructed for this research (Figure 1). Graphite rods, without catalysts coated, were installed in the center of the inner chambers as the anodes. The anodes were inoculated with the cultured *S. putrefaciens*, a dominant organism in the process of iron reduction in the iron rich soil of Northwest Florida. Carbon cloth (effective area of 12.6 cm^2, 30% wet proofing), coated with platinum catalysts (0.15 mg/cm^2, 5% Pt) was placed on the outside layer of the inner chamber, serving as the cathode. In the cathode chamber, O_2 served as the electron acceptor. The anodes and cathodes were connected through digital multimeters. Synthetic polymeric nanoporous membranes were used as the cation-exchange membrane (CEM).

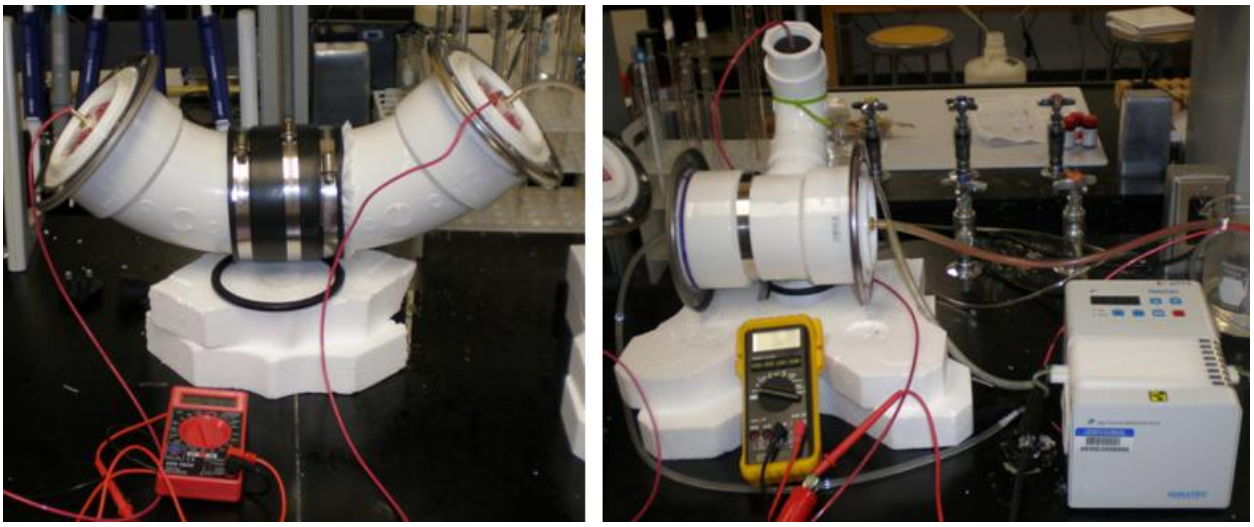

Figure 1. Batch MFC (Left) and Continuous MFC (Right) Setup

So far, we have tested glucose and landfill leachate from Quincy-Byrd Landfill (Gadsden County) in the batch MFC and glucose in the continuous MFC. As shown in Figure 2, glucose generated higher voltage (up to 0.4 V) as compared to that of landfill leachate (up to 0.1 V). In the continuous MFC, if the carbon source was continuously supplied, uninterrupted current was produced from the continuous MFC. We will continue testing landfill leachate from other fourteen landfills in these two MFCs to provide evidence that energy generation is possible from these carbon rich resources. We are currently setting up the pilot MCF facility to test iron release preventions using MFC technologies.

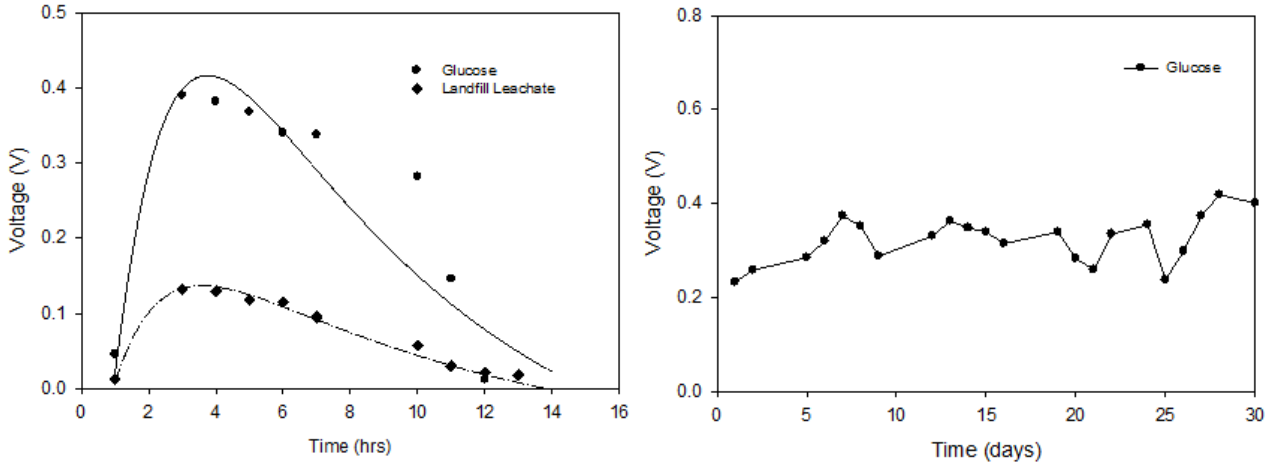

Figure 2. Voltage of the Batch and Continuous MFCs using Glucose and Landfill Leachate as the Carbon Sources

INFORMATION DISSEMINATION ACTIVITIES:
TAG members: Lee Martin, Peter Grasel, Casey Taylor, Jim Langenbach, Subramanian Ramakrishnan, Michael Watts, and Clayton Clark

TAG meetings: First TAG meeting was held on August 20, 2009 in RM B202 at FAMU-FSU College of Engineering. The meeting minute is available at www.eng.fsu.edu/~gchen.

CONFERENCE PRESENTATION:
Subramaniam, P. K. and Chen, G., Usage of microbial fuel cell technology to prevent iron release nearby landfills in Northwest Florida, 95th Annual SAM Southeastern Branch Conference, Savannah, GA, November 6 - 7, 2009.