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Toward improved monitoring and control of microbiologically influenced corrosion (MIC)

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Project Amount: \$98,139

Research Category: Pipeline Corrosion Detection and Monitoring

Objective(s) of the Research Project: Biofilm bacterial communities from a bench-scale flow loop ("bioloop") designed to provide a model system for the examination of pitting corrosion in pipelines are being assayed using PLFA and DNA-based molecular methods to determine which bacteria may be key members in corrosion-producing biofilms. An emphasis is placed on characterization of sulfate-reducing bacteria (SRB) due to their known potential for corrosion, however, the more general screening also planned for this project will allow detection of other types of bacteria that may promote corrosion.

Progress Summary/ Accomplishments:

1. Successful setup and operation of the BioLoops. A microbial inoculum for the BioLoops was freshly obtained from a three-phase pipeline conducting oil, oil-field brine, and gases from production wells on the North Slope of Alaska. The inoculum was enriched for sulfate-reducing bacteria in a synthetic brine containing sulfate and verified to have corrosive activity before being used to inoculate the 6 BioLoops. The significance of this accomplishment is that the inoculum was freshly derived from a field sample from an oil facility in which biocorrosion is an ongoing problem, thus it more closely approximates field conditions than experiments in which single strains are used. Duplicate BioLoops were run for each of three conditions: control (no additional chemicals), A (Corrosion Inhibitor A added continuously), B (Corrosion Inhibitor B added continuously). The Corrosion Inhibitors are those used commercially in the oil field, so analyzing their effect on MIC is very relevant to practical application and ensuring environmental protection from pipeline leaks.

2. Measurement of pitting corrosion on metal coupon samples from the BioLoops.

As well as standard weight loss measurements, a planar surface profilometer was used to provide a 3D map of the coupon surface. The significance of measuring pitting corrosion using the profilometer is that a more precise and detailed measurement of localized corrosion, indicative of biocorrosion, can be obtained. A significant finding was that inhibitor chemical treatments increased pitting rates on the coupons as compared to the untreated loop coupons. Practical applications are that particular corrosion inhibitors may be contraindicated if they prove to increase pitting rates.

3. PLFA analysis. Viable biomass levels and shifts in microbial community composition were assayed by analysis of PLFA from coupons, BioTraps, and BioStrips. A significant finding was that biomass levels were higher for each sample type for the treated bioloops than the untreated bioloops. This has a practical application in that particular corrosion inhibitors may be contraindicated if they increase microbial biomass levels. PLFA analysis revealed that corrosion inhibitors shifted the PLFA profiles of the microbial communities, with microbial communities from the untreated bioloops and bioloops treated with Corrosion inhibitor B appearing more similar than those treated with Corrosion inhibitor A.

4. DNA sequence analysis of samples. DNA was extracted from the working reservoir fluid, effluents from each of the Bioloops, SRB MPN bottles inoculated with bacteria obtained from metal coupons, directly from the metal coupons, and from BioTraps. PCR amplification, cloning, and sequence analysis is in progress but not yet completed for these samples. Preliminary results confirm that different microbial communities are growing on samples obtained from BioLoops subjected to different treatments, the communities contain a high proportion of SRB, including *Desulfovibrio* species that have previously been implicated in biocorrosion (Feio et al.), and other sequences are similar to those of Firmicute, Synergistes, and Chloroflexi obtained from previous studies of oil facilities. A practical application is that these laboratory studies were performed with diverse microbial communities similar to those found in oil facilities, therefore providing a more realistic test situation for biocides and corrosion inhibitors. Further sequence data and analysis will determine the association between specific microbial communities and higher levels of pitting corrosion. Practical application of this information will allow targeting of microbes strongly associated with corrosion. Comparisons of the microbial composition from different sample types obtained from the same BioLoops will allow design of better sampling protocols, as some types of samples more quickly provide higher levels of microbial biomass. A decrease in the period required for sample collection and increased test sensitivity due to greater biomass, would have practical application to monitoring and controlling biocorrosion.

5. In addition to the investigators listed above, two scientists contributed substantially to the success of this project.

Dr. Jennifer Busch Harris (ConocoPhillips Bartlesville Technology Center) was the lead scientist in setting up the microbial inoculum for the BioLoops and operating the BioLoops, as well as coordinating the distribution of the BioLoop sample devices to the various participants. She also performed the corrosion measurements, MPN studies, and was integral to the data analysis and generation of reports.

Dr. Beatriz Monica Perez-Ibarra joined the Duncan laboratory in January 2009 as a postdoctoral fellow funded by Consejo Nacional de Ciencia y Tecnología (CONACyT, Mexico) and has been assisting in the DNA-based portion of the research. Her efforts will allow additional types of samples to be analyzed.

Publications/ Presentations: No publications/presentations have been made during this time period, however, we anticipate (pending approval by ConocoPhillips) making a presentation at the 16th Annual Petroleum & Biofuels Environmental Conference November 3-5, 2009, Houston, TX

Future activities: We request a NCE in order to perform the future activities listed below. The major objectives and focus for the subsequent reporting period include 1. 16S rDNA gene sequences for coupons from all the BioLoops (this is well-underway) 2. *dsrAB* and/or APS sequence data, 3. 16S rDNA DGGE profiles for BioTraps and other sampling devices from the BioLoops (this is well-underway: Dr. Perez-Ibarra has extracted and amplified DNA from all the BioTraps), 4. Depending on funds available, generate 16S rDNA gene sequences for BioTraps and other sampling devices from the BioLoops.

Supplemental Keywords: pitting corrosion, sulfate-reducing bacteria, molecular probes, protection of groundwater and land, oil-field pipelines, pollution prevention, microbiology, petroleum industry, pipeline transportation.

Relevant Web Sites: No Web site has been established as part of the project.