3rd Quarterly Report:

Microbial Enhanced Energy Recovery Via The Production Of Methane From Residual Hydrocarbons In Oklahoma Reservoirs

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EPA Grant Number: X83242801
Title: Paraffin Control in Oil Wells Using Anaerobic Microorganisms
Investigators: J. M. Suflita
Institution: The University of Oklahoma
EPA Project Officer: Bala Krishnan
Project Period: 12-01-06 to 11-30-07
Project Amount: $80,000
Research Category: Pollution Prevention

Objective(s) of the Research Project: New technology is needed to recover the rather sizable amount of energy that is inherent in Oklahoma domestic oil reservoirs. A novel approach to this problem is the bioconversion of hydrocarbons entrained in marginally producing fields to methane gas as a cleaner-burning energy source. Thus, this project is designed to evaluate the utility of using an anaerobic bacterial consortium capable of converting oil in petroliferous reservoirs to methane and carbon dioxide. We will evaluate the efficiency and rate of oil bioconversion to methane by a methanogenic oil-degrading inoculum, identify the consortial members, and delineate the tolerance of the organisms to select ecological variables.

Progress Summary/ Accomplishments: In the previous report, results from a time course experiment were presented in which we evaluated the loss alkanes over time when a sandstone core sample constaining residual oil was inoculated with a hydrocarbon-degrading methanogenic consortium. Over the course of 4 months, we found that approximately 2/3 of the *n*-alkane fraction of the residual oil was depleted when the inoculum was added to the core material relative to sterile or uninoculated controls. Further, this alkane loss correlated with methane production. Interestingly, after 6 months of incubation, oil analysis showed little further depletion of any remaining alkanes (i.e. branched alkanes) but methane production ensued, suggesting that other fractions of the oil may also be subject to anaerobic decay (i.e., the PAH fraction). Other fractions of the residual oil will be examined for any evidence of biodegradation in a future experiment.

In the past reporting period, we established incubations for salt, temperature, and sulfate tolerance of the methanogenic, hydrocarbon-degrading consortium to determine its potential broad utility. We found that the methanogenic population is able to produce a comparable amount of methane in the presence of up to 2% NaCl (Figure 1A), despite its freshwater origin. On the other hand, the inoculum did not produce substantial amounts of methane from residual oil when incubated at temperatures higher than room temperature (approx. 22°C; Figure 1B). We will repeat this temperature experiment to

confirm these results and make attempts to acclimate the population to at least higher mesophilic conditions (i.e. up to 40°C).

The marginal sandstone core used for our experiments routinely yielded low levels of sulfate (< 4 mM) to the medium and we repeatedly observed that this alternate electron acceptor was simultaneously depleted as methane was produced. However, neither the rate nor extent of methanogenesis was impeded by sulfate. For example, the onset of methanogenesis was slightly delayed when 10 mM sulfate was exogenously provided to the incubations, but the extent of methane production after approximately 150 d was equivalent under the two conditions (Figure 1C). In fact, sulfate was not consumed in the cultures until after a lengthy lag period and long after the onset of methanogenesis (i.e. after 130 days, data not shown). Thus, the consortium was able to produce methane to almost equal extents under freshwater or marine conditions and in the presence of sulfate, suggesting that it may be useful for a variety of marginal wells, at least under mesophilic conditions.

Publications/ Presentations:

Gieg, L.M., Duncan, K.E., Suflita, J.M. 2007. Bioenergy Production: The Conversion of Residual and Unconventional Oil to Natural Gas. To be presented as an oral presentation at the IPEC meeting to be held in Houston, TX, November 6-9.

Future activities: We will continue to determine the potential broad utility of the residual oil-degrading inoculum by examining methane production from a variety of other petroliferous materials. Tools of molecular biology are currently being used to help identify the microorganisms present in the methanogenic inoculum.

Supplemental Keywords: Anaerobic biodegradation; Methanogenesis; Marginal Wells, Enhanced Energy Recovery

Relevant Web Sites: Not applicable at this time.

Figure 1. Methane production from residual oil under various conditions.