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Status Report

ENVIRONMENTAL EFFECTS OF MICROBIAL ENHANCED OIL RECOVERY PROCESSES

Project BE3, Milestone 4 and 5
FY86 Annual Research Plan

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INTRODUCTION

This status report addresses key milestones 4 and 5 of the FY86 Annual Plan for BE3. These milestones are: Preliminary Design for Microbial Field Compatibility Test Developed; and Recommendation on Continuation of Field Testing.

A consistent objective of BE3 has been to determine guidelines for performing microbial enhanced oil recovery (MEOR) processes in the field. Laboratory research has focused upon the compatibility and behavior of microorganisms used for MEOR in porous media. Information from these compatibility experiments, along with continual reviews of current MEOR literature, has been used to design a field MEOR compatibility test. This test has several objectives: (1) to determine the best available and scientifically accurate method for sampling and monitoring microorganisms in the oilfield; (2) to obtain information about what microorganisms are indigenous to that particular field; (3) to correlate a laboratory research effort with this field test so that some predictions can be made about the outcome; (4) to develop a set of guidelines for other field MEOR projects so that any environmental concerns could be addressed and satisfied; and (5) to provide recommendations for future MEOR field research. To perform and monitor a successful microbial field compatibility test, an important parameter is the preliminary design and planning.

SELECTION OF THE TARGET RESERVOIR

For a successful microbial treatment and simulation of an enhanced oil recovery field test, reservoirs selected must meet some minimum requirements. These constraints to MEOR processes have previously been reported by this laboratory.[1] Two relevant reservoir characteristics are

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salinity and temperature. Properties of each reservoir will have some variation; therefore, analyses of the water, oil, and rock from each well identified as a candidate for the field test will be necessary. This examination will eliminate the potential of an unusual element or trace mineral being present in a concentration high enough to be toxic to the microbial system to be injected. Although not common, some reservoir fluids may contain unusually high concentrations of metals. All microbes require certain heavy metals, including Co, Cu, Fe, Mn and Zn, in their nutrition. The toxic concentration of heavy metals for microorganisms varies of course, depending upon the microbe and the metal. An average toxic concentration of As, Cd, Cu, Sb, U, and V would be anything greater than 10^{-4} M. Fe would be toxic at a concentration higher than 10^{-3} M. The more information available about geological characteristics, drilling logs, and workover and production history, the more reliability that can be placed upon the field test. Downhole logs, pressure buildup analyses, and surveys can provide average properties of reservoirs over from several feet to several hundred feet of vertical section. These sources can yield information at a greater distance from the wellbore, but none yields as much information on the vertical section properties and heterogeneity at the well bore as can be obtained from core studies. For a proper and more complete field pilot test, core sampling should be undertaken.

One type of wireline coring tool allows a center plug to be recovered from the drill bit so that cores can be sampled at any selected depth. This tool runs at the bottom of drillstrings and supplies continuous vertical sections of core from 2 to 8 inches in diameter from which the desired information can be derived. An added advantage of coring wells is the ability to sample cores for the microbial flora downhole. A great concern of any microbial sampling operation is that by only sampling the formation water, a true representation of the microbial flora in the reservoir itself is not obtained. If such a core can be drilled and quickly chilled and placed in a sterile container, then the microorganisms obtained from the core should be the most representative of the true reservoir microflora. Since the coring objective for this microbial application is to obtain samples rather than determine residual oil/water/gas saturations, the relative cost should be the least expensive of all coring operations. Conventional coring operations could be used for this project, instead of pressure coring, sponge barrel coring, or sidewall coring. To obtain microbial samples from such cores, only a minimal amount of rock is needed; however, the larger the core the more easily it can be recovered. This coring procedure may be modified, depending upon the reservoir selected.

A history of previous waterflood production and well response must be obtained for this environmental compatibility test. A reservoir that has been waterflooded will probably contain an entirely different population of microorganisms than one that has not, and if it is still under waterflood, the microbial population may be dynamic, possibly changing every 24 hours. Use of two different wells would be desirable: one that is under a waterflood, and one that is not. This would give information on the variance in microbial populations and whether an MEOR process injection would behave differently in the two wells.

In addition to obtaining core samples, fluid samples will be taken from the wellhead, the injection water supply, and the tank battery. These samples will provide a baseline to determine the types of microbial flora being introduced into the well before the MEOR injection. The fluid samples will be packed in ice, protected from light, and transported immediately to the laboratory. Samples from the well, water supply and tank battery will be collected in aerobic and anaerobic sampling bottles. This will provide data on both types of microbial populations, since some microorganisms under aerobic conditions tend to overgrow anaerobic microbes unless separate environments are maintained.

LABORATORY ANALYSES OF SAMPLES

Formation water samples will be analyzed for chemicals that might be harmful to the selected microorganisms and for the indigenous microbial flora. Test tube microcosm studies with the rock, water, oil, and test microbial samples will be done to select the optimal combination of microorganisms for the field test. Selecting a microbial system that can be easily detected in the field and able to be isolated from other microbial flora that one might encounter will be important.

A main environmental concern of MEOR processes is the possibility of microbial migration into a freshwater aquifer or drinking water supply. A mathematical model for MEOR processes and transport through rock is lacking at present due to the complexity of MEOR systems. However, using linear cores in the laboratory will indicate the potential for the microbial system to migrate through porous media. If these data indicate that microbial migration may be a problem, then a decision to sample nearby wells (if available) will be made. From previous laboratory work at NIPER a data bank of information relating to survival of the microbial system in porous media has been developed.[2] This information will be combined with results of the core tests to design a sampling protocol during and after the field test, indicating necessary sampling times, and media for microbial examination.

WELL INJECTION PROCEDURE AND MONITORING

An injection schedule and sampling procedure will be determined. A time period will be designed for sampling based on the laboratory results. Bacterial counts, gas and oil samples, and wellhead pressure data will be recorded, and observations will be made for any changes in the surrounding wells. The data obtained during this period will be compared to the baseline data performed before well injection. The samples taken will be monitored to determine whether any harmful products have been produced by the microbial system. Some experimental procedures will include (1) toxicity testing, probably using mice; (2) Ames testing, to determine if the bacteria are producing any mutagenic compounds and thus indicating a carcinogenic potential; and (3) gas and high pressure liquid chromatographic analyses to provide support information for toxicity and Ames testing, should any positive results be obtained. In all cases, the data will be correlated with the laboratory results for simple and rapid methods to assess the environmental impact of MEOR processes. Such information will be used to modify and predict future MEOR field testing.

RECOMMENDATIONS FOR FUTURE MEOR FIELD TESTING

Over the past few years, many MEOR single-well field tests have been performed. Although published information on these tests remains scant, through various meetings and personal communication with other research scientists, NIPER concludes that MEOR processes can economically recover incremental oil. The major problem with the development of MEOR technology has been the lack of a coordinated effort among microbiological, geological, and engineering disciplines.

Progress has been made; however, and the future of MEOR appears to be bright for several reasons: (1) MEOR is one of the most economical processes for recovering more oil from petroleum reservoirs, especially when compared to other EOR processes such as chemical flooding or steamflooding; (2) the gap between the necessary MEOR personnel has been bridged; and (3) knowledge about MEOR processes has increased greatly in the past 5 years, and based upon that information, the technology has still proved feasible. A concerted effort to build MEOR technology in the field can only be more fruitful for the United States Department of Energy.

REFERENCE

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