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Development of Biosurfactant-Based Technologies for Enhanced Oil Recovery and Sulfide Reduction

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EXECUTIVE SUMMARY

Currently, one-half to two thirds of the original oil remains in reservoirs for tertiary recovery within Canada. The fast-growing demand for Enhanced Oil Recovery (EOR) technologies is related to a multi-million dollar marketplace. However, many EOR technologies are associated with various difficulties, such as high capital requirement, system complexity, secondary pollution, and hydrogen sulfide production. Previously, numerous studies were conducted to address individual problems and/or processes related to either EOR or sulfides elimination. However, there were few trials on effective technologies that are suitable for EOR together with sulfides (mainly H_2S) elimination. Moreover, most of the existing trials were limited to the introduction of traditional chemicals (e.g. surfactants, nutrients). More in-depth R&D of innovative technologies for facilitating EOR and eliminating sulfides simultaneously is desired for sustainable and cost-effective production of the Canadian petroleum industry.

Biosurfactants are a diverse group of surface-active chemical compounds, which are amphiphilic molecules with both hydrophilic and hydrophobic domains. They can partition at the interface of two fluids with differing polarities such as oil-water or water-air interfaces, thus capable of reducing the interfacial and/or surface tension. Such properties make them good candidates for enhanced oil recovery. Biosurfactants can be produced as intermediate products of microbial activities. The most critical issue associated with the biosurfactant development and application is to determine whether an additional biosurfactant will promote (or limit) activities of the inherent microorganisms. After playing the roles of improving media conditions and promoting microbial activities, the biosurfactant (as an organic matter) could then be used as a preferential substrate by inherent microorganisms. Ideally, a biosurfactant should be degradable by the microorganisms at a slow rate to maintain its enhancement effectiveness.

The main challenge of using this technology is the difficulties in determining the matchable biosurfactants under complex reservoir conditions. In this project, the following approach was proposed to solve the problem. Water/oil samples in the reservoirs will be acquired from a western Canadian site. Inherent microorganisms will be screened in the customized media, where the petroleum products appear as the carbon source and specific nitrate-based liquid acts as the nitrogen source. The obtained biosurfactants can then well match the indigenous microorganisms. Further, those biosurfactants will be characterized through chemical and biological analyses,

followed by the production using the specified nitrate-reducing bacteria in lab and then be potentially extended to industries for bulk production.

This research, for the **first time** in petroleum industry, will focus on the development of innovative biosurfactant-based technologies for EOR and H_2S elimination. The appropriate biosurfactants, different from conventional chemical surfactants, will be screened with special characteristics of being (a) able to improve oil recovery processes, (b) of no secondary pollution, (c) able to inhibit the production of H_2S, and (d) able to be operated easily and economically. The research outputs will provide technical and methodological supports for petroleum industries with improved cost-effectiveness and efficiencies.

The research project was divided into a series of tasks that were designed to determine the feasibility of the developed biosurfactants enhanced oil recovery technology as well as the inhibition of hydrogen sulfide. The experiment works were successfully accomplished, focusing on stimulating in situ microbial products and metabolic processes to enhance oil recovery, and analyzing the inhibition of H_2S production through the injection of nitrates. In task 1, microorganisms were isolated from the produced water in western Canadian oil field and their potential for biosurfactant/bioemulsifier production was investigated. Several promising strains were further characterized in terms of the surface-active properties of metabolites produced. In task 2, nitrate-reducing bacteria (NRB) and sulfur reducing bacteria (SRB) were isolated and characterized respectively from the produced water of oil field. The isolated strains were further applied in the task 3, where the effects of nutrient amendment on the competition growth of NRB and SRB were evaluated through bacteria enumeration and nutrient-concentration determination. In task 4, the effects of biosurfactant and its stimulation on oil recovery under various flooding regimes in sand-packed column were investigated. The experimental results, addressing the effects of the biosurfactants on oil recovery, were complied and reported in a form that could facilitate technology transfer to the oil industry for commercial applications. Performance of the developed biosurfactants and the associated technologies under real reservoir conditions within a Canadian context will be examined in further studies.

The research outputs are expected to (i) improve production and reduce cost of oil recovery, (ii) offer simple and inexpensive application protocols, (iii) reduce corrosion-related production equipment costs, and (iv) provide safer working conditions.

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