New strategies to develop and apply biotechnological processes in mature oil fields

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Introduction

Discovered many years ago, biotechnological methods for enhancement of oil recovery and souring control are still on the corner just because there are many resistances to apply them in oil industries. These methods have been proven highly efficient and diverse, most case environmentally safe, and relatively cheap although science-intensive. There are some criteria, which have to be followed to achieve better efficiency for enhancing oil recovery and souring control based on the geochemical activity of microorganisms and their products. To be successful, the complexity of oil and the physical constraints in the reservoir must be taken into account. The three general approaches are: stimulation of the endogenous microbial population; injection of microorganisms with proven ability to perform well *in situ;* and the use of microbial products, such as polysaccharide gums and surfactant produced by many types of microorganisms. Biocompetitive exclusion (BCE) technology is a biotechnological process based on the stimulation of beneficial rock endogenous microorganisms named petrobiotics, which work inhibiting or competing with sulfate-reducing microorganisms (SRM).

Microbial Enhanced Oil Recovery

MEOR involves stimulating native reservoir microbes or injecting specially selected consortia of bacteria into the reservoir to produce specific metabolic products and mechanisms to improve oil recovery. This also can be achieved by flooding with the oil recovered bioagents produced *ex situ* by industrial scale fermentation. Microbial technologies are becoming accepted worldwide as cost-effective and environmentally sound solutions for enhancing oil production. Microorganisms produce a variety of

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products that are able to improve unfavorable properties of different types of oil and increase recovery. Microbial products can reduce oil viscosity and cause crude oil to swell, alter rock surface wettability, lower interfacial tension, and form stable oil-water emulsions which have improved mobility and transport properties. Although microbial oil recovery methods have been proved highly efficient and diverse, it is necessary many studies before their field implementation. Physical and geochemical activity of microorganisms such as their ability to attach, colonize, spreading and maintenance of their desirable metabolic activities in the rocks and/or in oil strata are necessary to improve oil recovery or to control souring. In some cases where microorganisms are able to metabolize hydrocarbons, injection of inorganic nutrients, such as nitrogen and phosphorous, is capable to stimulate growth of *in situ* microbes. This process diverts injection, thereby improving sweep efficiency. The nutrients stimulate growth of *in situ* microbes, not injected microbes, diverting water flow from more porous zones to unswept zones, increasing waterflood sweep efficiency. It is a reservoir process, not just treatment of individual wells. When the reservoir does not have the microorganisms able to degrade oil hydrocarbons, organic carbon sources have to be added in order to maintain the biochemical microbial activities and to synthesize oil-releasing agents such as CO_2, CH_4, fatty acids, alcohols, polysaccharides, surfactants, and other bioactive substances. These processes are easily to control because nutrients have to be added to the oil field in order to stimulate growth of microorganisms capable of *in situ* production of oil-releasing substances directly in zones and microzones containing residual oil. Most complex and expenses biotechnological processes involve the addition of nutrients and microorganisms to the oil reservoirs. Present research that helps to develop biotechnology for oil recovery enhancement should be concerned with study of the regularities of microbial distribution and geochemical activity in oil fields under different geophysical conditions, as well as with advanced investigation of physiological and biochemical characteristics of microorganisms and development of methods for regulation of microbial processes in oil fields. A new and exciting experience also involves flooding with oil recovery agents produced *ex situ* by selected microorganisms in industrial scale fermentation.

Biocompetitive Exclusion Technology for souring control

Although application of biocides is probably the commonest method of controlling biocorrosion or souring the efficiency of biocides has already been condemn for many reasons including considerable toxic properties and environmental impact. More recently, biological approaches have been applied to control souring in oil fields based on the principle of the BCE. Biotechnological processes have been stimulated to control SRM through the formation of beneficial and stable biofilm that keep growing many types of nitrate, nitrite, molybdate and tungstate reducing bacteria or petrobiotic bacteria. The BCE technology involves the addition of selected nutrient salts formulation to enhance growth of an existing microbial population as cited, and as side effect they can improve oil recovery.