Available online at www.sciencedirect.com
ScienceDirect
Current Opinion in Microbiology

Microbial enhanced oil recovery (MEOR)

Lewis R Brown

Two-thirds of the oil ever found is still in the ground even after primary and secondary production. Microbial enhanced oil recovery (MEOR) is one of the tertiary methods purported to increase oil recovery. Since 1946 more than 400 patents on MEOR have been issued, but none has gained acceptance by the oil industry. Most of the literature on MEOR is from laboratory experiments or from field trials of insufficient duration or that lack convincing proof of the process. Several authors have made recommendations required to establish MEOR as a viable method to enhance oil recovery, and until these tests are performed, MEOR will remain an unproven concept rather than a highly desirable reality.

Address
Mississippi State University, Biological Sciences, 449 Hardy Road, Room 131 Etheredge Hall, P.O. Box GY, Mississippi State, MS 39762, United States

Corresponding author: Brown, Lewis R (lrbsr@ra.msstate.edu)

Current Opinion in Microbiology 2010, **13**:316–320

This review comes from a themed issue on
Ecology and Industrial Microbiology
Edited by Erick Vandamme

Available online 9th February 2010

1369-5274/$ – see front matter
© 2010 Elsevier Ltd. All rights reserved.

DOI 10.1016/j.mib.2010.01.011

Introduction

The first production from an oil well is the result of the pressure of the earth's overburden on the oil-bearing formation or by pumping. As this primary production declines, some of the wells are converted to injector wells and either waterflooding or sometimes gas flooding are implemented. Even after this secondary production effort has reached its economic limit, two-thirds of the original oil in place is still left in the ground and tertiary measures may be employed. These include chemical enhanced oil recovery (EOR) methods such as polymer flooding, surfactant flooding, alkaline flooding, etc. or the use of thermal measures such as injection of steam or in situ combustion.

Another tertiary method of oil recovery is microbial enhanced oil recovery, commonly referred to as MEOR. Actually, there are several ways in which microorganisms can enhance oil recovery other than what is commonly referred to as MEOR. For example, microorganisms can be used to reduce the paraffin build-up in producing wells or they can be utilized to produce solvents or polymers above ground for pumping into the oil-bearing formation as in EOR. In reality, the only difference between EOR and some of the MEOR methods is the means by which the recovery-enhancing chemicals are introduced into the reservoir [1]. Normally, however, MEOR refers to the use of microorganisms in the oil-bearing formation itself to enhance oil recovery.

Review of MEOR

Beckman first proposed MEOR in 1926, but it was not until the work of ZoBell and Russian investigators in the 1940s that any serious consideration was given to the process [2–6]. It must be remembered that microbiology as a science was less than 100 years old at the time and the ability of microorganisms to use hydrocarbons was viewed as a biological curiosity. Most of the research was conducted in university laboratories and it was not until the 1940s that an oil company in the U.S. actually hired a microbiologist.

ZoBell's first patent [3] involved the injection of the bacterium *Desulfovibrio hydrocarbonoclasticus* along with oxidized sulfur compounds and a carbon source, such as lactose, but no field trials were performed. In a latter patent, ZoBell introduced the concept of adding oxygen-free hydrogen produced by the action of a *Clostridium* species on a carbohydrate [7]. In the same year, Updegraff and Wren [8] patented an MEOR method involving the injection of a species of *Desulfovibrio*, a symbiont bacterium, and molasses into the formation. Once again, however, no actual field tests were attempted.

Although some microorganisms can grow on oil, it must be remembered that during the early years of MEOR, it had not been conclusively proven that microorganisms could actually metabolize the hydrocarbons anaerobically, and virtually nothing was known about the microbiology of oil-bearing formations. As a matter of fact, it was not until recently that bacteria have been shown conclusively to metabolize hydrocarbons in oil anaerobically [9,10].

There is absolutely no question as to weather microorganisms have the capability of enhancing oil recovery by virtue of some of the products they can produce. For example, bacteria can produce acids from oil and other organic compounds which will dissolve carbonates, thereby increasing permeability as shown in Figure 1. They can also produce gases that increase pressure in the reservoir and decrease the viscosity of the oil by dissolving in it. Biosurfactants, emulsifiers, and solvents

Figure 1

Current Opinion in Microbiology

Cores obtained from North Blowhorn Creek Unit after treatment in the laboratory. Core on the left only had simulated production water pumped through it daily. Core on the right had simulated production water containing 0.12% (w/v) potassium nitrate passed through it on Mondays and 0.034% (w/v) sodium dihydrogen phosphate passed through it on Wednesdays and Fridays. On Tuesday, Thursday, Saturday, and Sunday, simulated production water only was pumped through this core. Note destruction of portions of the core on the right after treatment [31].

decrease the viscosity of oil making it easier to produce (as shown in Figure 2), or they can produce biopolymers that increase the viscosity of the water in waterflooding operations, making the operation more effective. By increasing in number, the bacteria will selectively plug the oil-bearing formation and alter the water injection profile in a waterflooding operation. Therefore, the question is not whether microorganisms can enhance oil recovery, but rather how to employ this ability in an economically practical and scientifically valid manner.

A majority of the MEOR processes, particularly the early methods, involved injecting microorganisms into the reservoir. Unfortunately, some operators have had bad experiences during normal waterflooding operations because microorganisms have caused the plugging of wells or they have contributed to corrosion problems by producing hydrogen sulfide. Interestingly enough, Beck [11] and O'Bryan and Ling [12] experienced some plugging by the injected bacteria in their laboratory studies of MEOR. It has been suggested that not only will the bacteria themselves cause plugging, but also the by-products of their metabolism, such as ferric hydroxide, will cause plugging [13].

It is obvious that injected microorganisms will have difficulty penetrating into the oil-bearing formation. This led Hitzman [14•] to propose using spores instead of vegetative cells because of their smaller size. Even so, spores also create plugging problems and Lapin-Scott *et al.* [15•] proposed using ultramicrobacteria (UMB) that have a diameter of less than 0.3 μm. Jack *et al.* [16] calculated that the microbes injected into oil sands needed to be small and spherical and less than 20% of the size of the pore throat in the formation. Even if the injected microorganisms meet the size criterion, they cannot be metabolically producing gases, polymers, or slime of any kind at the time of injection, since that would inhibit penetration through the formation. According to Davis and Updegraff, the pore entry diameter should be at least twice the diameter of the microbial cells being injected; otherwise serious plugging will occur [17].

The hazard exists that the injected bacteria themselves may cause the plugging of the oil-bearing reservoir. To prevent this from happening, Chang and Yen [18] suggest using a lysogenic strain of bacteria. They state 'It may be possible to use bacteria carrying inducible latent phage, potentially triggered by reduction of a specific substrate level, presence of a certain cell density, concentration of by-product, or application of some subsequent oil recovery agent.'

According to Yen [19] a wide variety of chemicals have been proposed to prevent bacterial activity in oil-bearing formations and Hitzman [20] even patented the concept of adding a biocide to the water in a waterflood to kill or inhibit sulfate-reducing bacteria because of the hydrogen sulfide they produce. In regard to MEOR, one suggestion is to use a bacterium resistant to the biocide being employed [19].

Nevertheless, research on MEOR continued and by 1990 there had been 133 U.S. patents issued in addition to a number of patents in other countries [19]. By 2003 more

Figure 2

Current Opinion in Microbiology

Cores obtained from North Blowhorn Creek Unit after treatment in the laboratory. Core on the left only had simulated production water pumped through it daily. Core on the right had simulated production water containing 0.12% (w/v) potassium nitrate passed through it on Mondays and 0.034% (w/v) sodium dihydrogen phosphate passed through it on Wednesdays and Fridays. On Tuesday, Thursday, Saturday, and Sunday, simulated production water only was pumped through this core. Note removal of oil from the core after treatment [31].

Download English Version:

https://daneshyari.com/en/article/3399167

Download Persian Version:

https://daneshyari.com/article/3399167

Daneshyari.com