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Experimental study of effect of microbial enhanced oil recovery on rag Sefid reservoir

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Abstract
In this work, we separate microorganisms from soil sample of Rag Sefid reservoir to produce bio-surfactant. This microorganism is belonging to Alcaligenes Sp family that the microorganism able to produce bio-surfactant. After produced bio-surfactant used for decrease interfacial tension between oil sample and water. Effect of four factors such as temperature, NacL concentration, pH and ratio of C/N on interfacial tension, were investigate. The experimental results shown the pH was not affected same as another factors. We were performed 16 experimental runs to reduce interfacial tension between oil and water and increase enhanced oil recovery in the core sample. Permeability of core was 54 m-Darcy. Minimum interfacial tension obtained was 20 mN/m. Results of core injection shown that maximum enhanced oil recovery was 11% and minimum enhanced oil recovery was 5%.

Keywords: Bio-surfactant, Rag Sefid reservoir, Interfacial tension, Oil recovery

1. Introduction

A one of microorganism applications is use in to the oil industry. Use of bio-surfactant in the enhanced oil recovery was not new method. Beckman suggested for the first time that microorganisms could be used to produce oil from reservoir rock (Bekman 1926). After that, ZoBell *et al* (1947) [2] made a systematic laboratory to microbial enhanced oil recovery investigations. Their results caused to start a new era of research in microbiology to use for enhanced oil recovery. He explained and reported which bacterial products gases, acids, solvents, bio-surfactant, and cell biomass, enhanced oil recovery from sand pack columns in laboratory tests. Bio-surfactants are a group of surface active molecules that are produced by a variety of microorganisms. Like chemical surfactants, bio-surfactants have hydrophobic and hydrophilic moieties. The hydrophilic moiety of a bio-surfactant is a carbo-hydrate (mono, di, or polysaccharides), an amino acid or a peptide, and the hydrophobic moiety is a saturated or unsatu-rated fatty acid and accordingly bio-surfactants are classified as glycolipides, lipoproteins, lipopeptides, polymeric, and parti-culate bio-surfactants (Don, *et al*, 2003. and Desai, *et al*, 1997) [5, 4] Due to environmental concerns about the use of chemical sur-factants, there is a growing interest to replace these chemicals by bio-surfactants. The potential applications of bio-surfactants have been examined in different areas. Bio-surfactants have been used in flotation for the removal of metal ions, in biore-mediation, in enhanced oil recovery processes, in gene trans-fer, and in food, pharmaceutical, and cosmetic industries (Christova, *et al*. 2004, Strappa, 2004, Gregory, *et al*. 2004) [3, 11, 7] Dif-ferent microbial species have been used in bio-surfactant pro-duction. Among the species cited in the literature are Pseudo-monas putida (Strappa, *et al*, 2004, Ghadiri, 2003, Syyoun., *et al*, 2002) [11, 6, 12] Actinomycetes, Bacillus subtilis, Lactococcus lactis, Lactoba-cillus strains (Rodrigues, *et al*, 2006, Rodrigues, *et al*, 2006.) [8, 9], Streptococcus thermophilus, Bacillus licheniformis, Pseudomonas aeruginosa, Nocardioides sp. Bacillus pumilus, Aeromonas sp. Ser-ratia sp. Rhodococcus strains, and Candida ingens (Rodrigues, *et al*, 2006) [8].

Both soluble and insoluble carbon substrates have been used for bio-surfactant production. Glucose, glycerol, cheese whey, molasses are soluble substrates that have been tested for bio-surfactant production. Among insoluble substrates, different kinds of vegetable oils and different hydrocarbons have been used to produce bio-surfactants. Insoluble substrates have been reported to be superior in bio-surfactant production (Saikr shna, *et al*, 2007., Rodrigues, *et al*, 2006, Rodrigues, *et al*, 2006.) [10, 8, 9].

The advantage of bacteria in oil recovery is a well-known phe-nomenon. Bacteria can enhance oil recovery in different ways. They produce gases like carbon dioxide, organic solvents and some surface-active agents (bio-surfactant). All these can help oil mobilization in reservoirs.

Active microorganisms can grow in the reservoirs and block larger pores. This causes the fluid to pass through smaller pores in subsequent flooding. Three methods have been suggested for microbial enhanced oil recovery. In the first method, bio-surfactant and/or organic solvents are produced at the surface and the whole fermenta-tion medium is then introduced to the reservoir. In the second method, proper microbes introduced to the reservoir for in situ production of gases, solvents, and bio-surfactants. In the third method, only selected nutrients are injected to the reser-voir to stimulate the activity of indigenous bacteria (Rodri-gues, *et al*, 2006) [8]. The disadvantage of injecting the whole fer-mentation medium to the wells is that the concentration of the useful components like organic solvents and bio-surfactants might not be high enough to be effective. Moreover, the fer-mentation medium contains various constitutes like mineral salts and carbohydrates that contaminate the reservoir without contributing to enhanced oil recovery. The second and third methods are applicable only to those reservoirs having com-patible environmental conditions (pH, temperature, salinity, nutrient availability) for microbial growth. The drawback for all the three methods is that the efficiency of the methods is not predictable and field trial needs to be done for each specif-ic reservoir (Ghadiri, 2003, Syyoun, 2002, Gregory, 2002, Saikr-shna, 2007, Rodrigues, *et al*, 2006) [6, 12, 7, 10, 8].

Ex situ production and purification of bio-surfactants, and application in enhanced oil recovery in known concentrations, is an alternative to the existing MEOR methods. Bio-surfactants can replace the chemical surfactants. The application of bio-surfactants in purified or concentrated forms has not been widely investigated. It generally believed that using bio-surfactants in purified or concentrated forms are costly.

In this research, we propose a simple method for simultaneous production and separation of a bio-surfactant and its application to enhanced oil recovery from core sample of Rag Sefid reservoir.

2 Materials and Methods

2.1 Material

In this investigation used following Material:

$NaNO_3$, K_2HPO_4, KH_2PO_4, KCl ,$MgSO_4.7H_2O$, Agar, NaCl, Beef extract, Trypton, $CaCl_2$, $FeSO_4.7H_2O$, Yeast extract, NH_4Cl, Glycerol, Na_2HPO_4, CTAB, Methlene blue, $(NH_4)_6Mo7O_{24}$, $MnSO_4$

2.2 Microbial cultivation

Crude oil obtained from Rag Sefid reservoir to produce bio-surfactant. We were produced bio-surfactant in order to enhanced oil recovery in this reservoir.

Microorganism separated of crude oil by general method same as E24. This materials that shown in table 1, used to microbial cultivation for produce bio-surfactant, purchased from Merck Company.

Table 1: selective microbial cultivation M1 for separating microorganism

material	gl^{-1}
$NaNo_3$	7
KH_2PO_4	0.5
K_2HPO_4	1
KCl	0.1
$MgSO_4.7H_2O$	0.5
$CaCl_2.2H_2O$	0.01
$FeSo_4.7H_2O$	0.01
Yeast extract	0.1

We have two flaskes microbial cultivation include 200ml and 250ml. In this cultivation at the first, we used glucose as carbon source. Then added 2 percent crude oil to any flask and put in shaker with 160 rpm and 30 0C for 4 days. After that added any sample to cultivation surrounding for produce bio-surfactant.

2.3 Injection tests

The goal of injected was study effect of bio-surfactant on reservoir rock and fluids. Core holder has capability to set of pressure and temperature (figure 1).

The core sample obtained from Rag Sefid reservoir. This core has permeability, porosity and initial water saturation respectively 50 md, 15% and 19%.

Fig 1: core holder

Before inject bio-surfactant, core sample saturated with brine and crude oil respectively. In this test, we injected 2 pv bio-surfactant solution with rate of 40-20 cc/hr for 2400 minutes.

3. Result and discussion

Figure 2 shown result of water injected in the core for enhanced oil recovery. That results shown 40% recovery after about 1000 minutes.

Figure 3 shows the result of bio-surfactant solution that injected in to the core sample. After 2400 minutes, we seen around of 10% oil recover from thin injected.

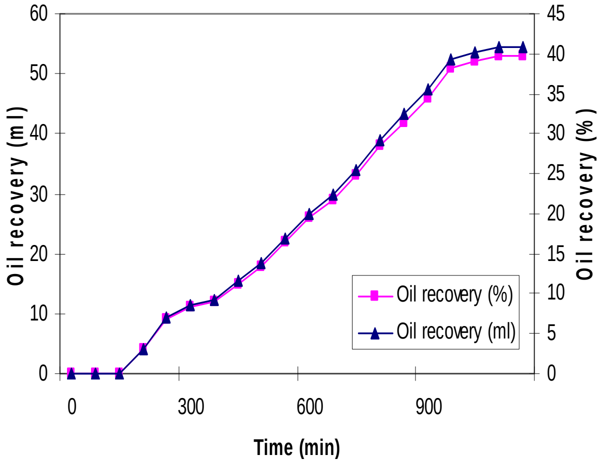

Fig 2: Effect of water injected in core for EOR

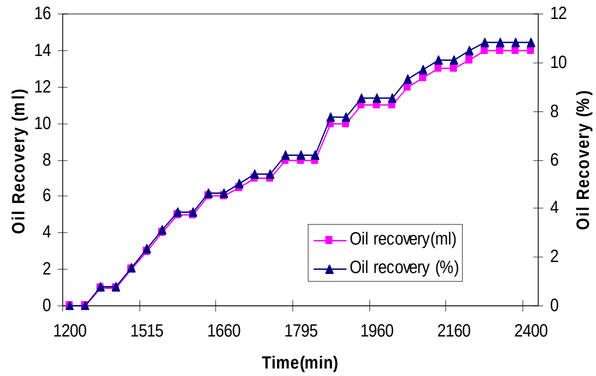

Fig 3: Effect of bio-surfactant solution injected in core for EOR

Then we injected water and bio-surfactant together in to the core sample (figure 4).

At the start until 1300 minutes of injection, we injected water and then injected bio-surfactant until 2500 minutes of start injected. The result shows 55% oil recovery that was be more than bio-surfactant and water injection.

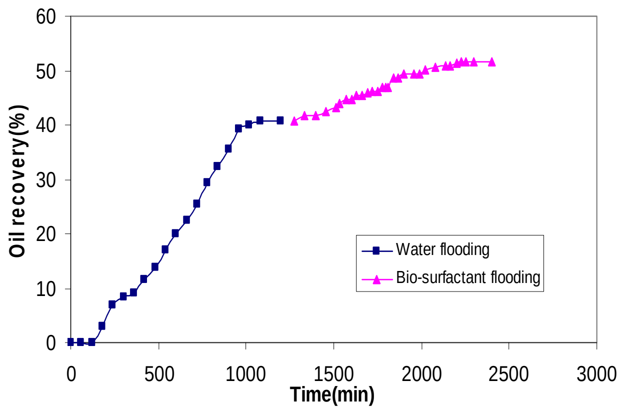

Fig 4: Effect of water/bio-surfactant together injected in core for EOR

4. Conclusion

In this investigation we separated bio-surfactant from crude oil sample of Rag Sefid reservoir that after injected in to the core sample we seen a good results.

In the injection program, we injected water, bio-surfactant and water/bio-surfactant in the core sample. After end of tests, we seen that injected water/bio-surfactant together showed oil recovery more than water and bio-surfactant injection.

5. References

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