Book of Abstracts
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Possibilities of Microbial Enhanced Oil Recovery in Danish chalk rocks

1. Summary

Microbial Enhanced Oil Recovery (MEOR) uses the injection of bacteria, producing gas (CO2), polymers or surfactants into the oil-saturated layer to help recover residual oil. Parameters such as high salinity, low permeability, high temperature and toxic elements, being typical characteristics of Danish fields can cause limiting effects on MEOR applications. Two strains of Clostridia tyrobutiricum were investigated as possible candidates for MEOR implementation in Danish chalk reservoir rocks. The work fulfilled showed that microbes can be adapted to higher salinities through a serial adaptation processes and our experimental microbes are able to survive, regenerate and produce gas and by-products in salinities of up to 20 g/l higher than salinities in which pure cultures can survive.

Titrimetric method, proposed to determine the percentage of CO2 in the total gas produced by microbes of strain 663 in microbial solution with salinity 50g/l, showed that 67 % of gas was produced in the presence of chalk and just 20% in the process of microbial fermentation with molasses (without chalk). Titrimetric analysis was used to measure the volume of acid produced by microbes which resulted in 0.21 millimoles per 1 ml of molasses during 14 days of fermentation period

The staying in microbial solution improved the permeability of three chalk samples by 8.1%, 16.4% and 2658% respectively during 14 days of exposure having formed a big hole in the core sample in the latter case.

Keywords: microbial oil recovery, Clostridia tyrobutiricum, salinity, MEOR, gas production

2. Extended Abstract

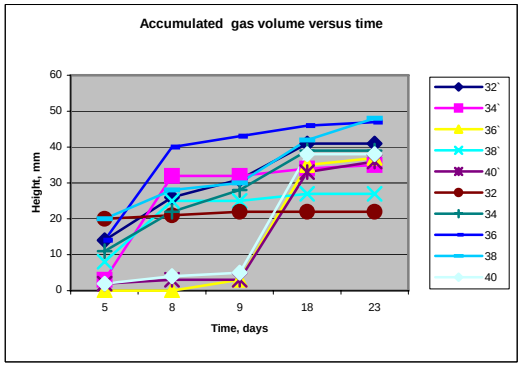
It was estimated that oil reserves of EU and Norway would be extracted in 25 years. In this connection, it is a good moment to recollect some of Enhanced Oil Recovery techniques which proved to be successful 50 years ago but because of apparent abundance of cheap oil seemed not to be needed. One of such method is Microbial Enhanced Oil Recovery (MEOR) which applies the injecting of microbes into oil-saturated layer to release oil.

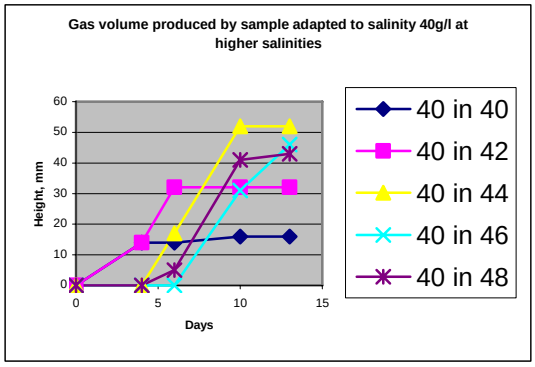
Microbes to be selected for MEOR purposes have to produce gases (mainly CO_2), acids and other products of metabolism and withstand harsh conditions of oil reservoir which are typical for Danish oilfields.

AAUE fulfilled a serial of experiments on adaptation of Clostridium tyrobutiricum (known gas-producers) to higher salinity, measurements of the volumes of CO_2 and acids produced, oil displacement by the gas, estimation of permeability changes in the result of reaction between chalk and acids.

I. Adaptation of microbes to higher salinities.

Pure culture of the strain 2637 in test tubes plugged with paraffin was able to produce gas till salinity 30 g/l only. From the tube with salinity 30g/l microbes firstly were put in the tubes with the series of salinities ranging from 32 to 40g/l and then taken from 40g/l were put in the next series of salinities changing from 40 to targeted 48 g/l, the actual salinity of one of the Danish oilfield. In all the tubes the gas appeared which proves that the whole population of microbes has acquired ability to adapt to higher salinity than microbes of pure culture.





Following the same procedure, the adaptation of strain 663 increased from 45 g/l till 70 g/l.

II. Gas and acid analysis.

Carbon dioxide is a main subject of our interest among other by-product of microbial metabolism because it pressurizes the oil reservoir and forms a miscible phase with oil reducing its viscosity. Percentage of CO_2 produced by microbes and dissolved in microbial solution with salinity 50 g/l, which is higher than pure culture of strain 663 can withstand, was measured using titrimetric method in and without presence of chalk. After applying of our calibration technique developed, the result of titration without chalk sample showed 20% of CO_2 in gas phase and 67% with chalk sample. As seen, the main volume of CO_2 dissolved in the microbial solution is due to the reaction between acid produced by microbes and chalks.

Titrimetric analysis was used to measure the volume of acid produced by microbes which resulted in 0.21 millimoles per 1 ml of molasses during 14 days of fermentation period. The results of gas and acid analysis showed that in more salty environment the famous gas-producing microbes produce more acid.

III. Permeability measurements.

Radial permeability of 3 chalk samples was measured before and after 14 days of staying in microbial solution with salinity 50 g/l. The water flowing through the chalk samples after staying in microbial solution was white, saturated with chalk particles in all the cases. The results of permeability are shown in the table below. In case of sample 4, a big hole appeared as the result of chalk dissolution.

Gas generation in reaction of chalk and acid

Results of permeability measurements

Sample	*K'pure'* 'miliDarcy'	*K'exposed'* 'milliDarcy'	Difference. 'milliDarcy'	Increase Permeability '%'
4	7,23	199,4	192.17	2657.9
10	6,11	7,11	1,00	16,36
11	6,28	6,79	0,51	8.12

Sample 4.

Conclusions:

- **Microbes can be adapted to higher salinities**
- **Total volume of CO_2 produced in microbial solution increases at 50% due to reaction between chalk and acid**
- **Permeability of chalk can increase significantly due to dissolution of chalk**

References

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