Possibilities of MEOR Implementation in Danish Chalk Oil Reservoirs

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Denmark is an oil exporting country, producing roughly twice the amount of oil it is consuming. An increaseof just 1% in the oil recovery from Danish fields would be sufficient to cover the country's demand for two years. Microbial Enhanced Oil Recovery (MEOR) offers a cheap way to increse oil recovery from low permeability Danish Chalk reservoirs. Svetlana Rudyk (sr@aaue.dk) and her fellow MEOR researchers (Leif Wagner Jorgenson, Julaine Enas and Jimoh Adetunji) at Aalborg University Esbjerg, Denmark have adapted microbes to withstand higher salinities. Here they present some of their experimental results.

Conditions in Danish Fields

The effect of MEOR applications can be limited by parameters such as high salinity, low permeability, high temperature and toxic elements. The task is to find anaerobic microbes, which simultaneously can withstand harsh conditions and produce by-products useful for MEOR purposes.

Danish fields have high salinities as many of them are adjacent to salt domes. According to some publications, the salinity of formation water increases from south to north from 100 to 300 g/l. Since we consider MEOR as a tertiary method which can be applied as a follow up after water injection, the salty formation water will be diluted with sea water injected into the formation. Produced water samples were therefore taken from one of the fields to estimate the reduction in water salinity as a result of such dilution. The salinity measurements showed 48 g/l which is much lower than the published values.

Results of Microbe Experiments

Following the recommendations of Wagner et al. (1997), who performed successful well treatments with Clostridium tyrobutyricum microbes, we purchased the strains of these microbes held in the DSMZ (German Collection of Microorganisms and Cell Cultures) collection to see how they can be adapted to higher salinities and temperatures.

Figure 1: Test tubes with microbial solution

Two different strains (I and II) of pure culture of Clostridium tyrobutyricum were put in test tubes with broth made up with various water salinities as shown in Figure 1.

Anaerobic conditions were secured by a paraffin plug. The volume of gas (CO2 and others) produced was measured in mm of height the paraffin plug was displaced. The pure culture of the strain I was able to produce gas only up to a salinity of 30 g/l.

From the tube with salinity 30 g/l, microbes were put in tubes with a series of salinities ranging from 32 to 40 g/l (with each tube duplicated). Gas appeared in all the tubes, indicating that the whole population of microbes had adapted to salinities higher than the microbes in the pure culture.

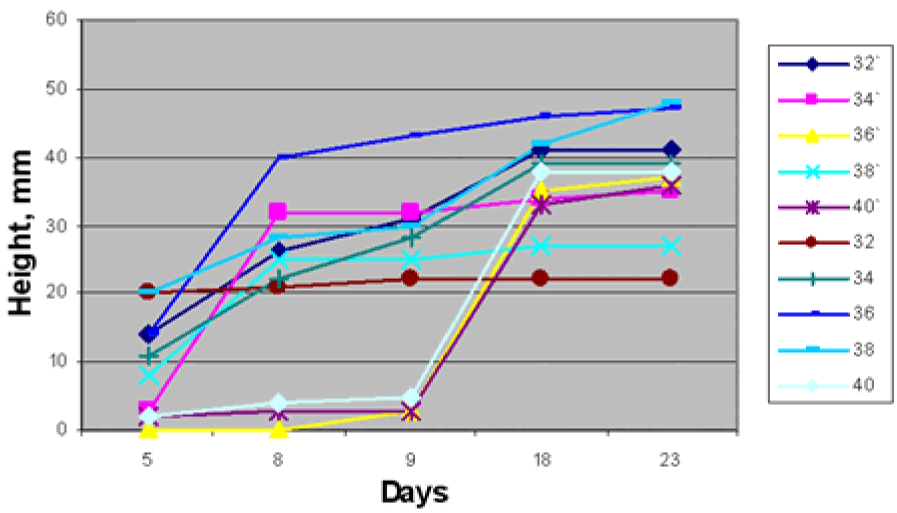

Figure 2: Graph of accumulated gas volume versus time

As shown in Figure 2, the lag period for microbes in both tubes with a 40 g/l salinity increased from

5 to 9 days compared to microbes in tubes with the lower salinities. The microbes in a tube with 36 g/l gave the highest gas production while 40 g/l showed the highest salinity adaptation. The next step was to take microbes from the tubes with 36 g/l and 40 g/l salinities and put them in the next row of tubes with salinities from 40 g/l to 50 g/l.

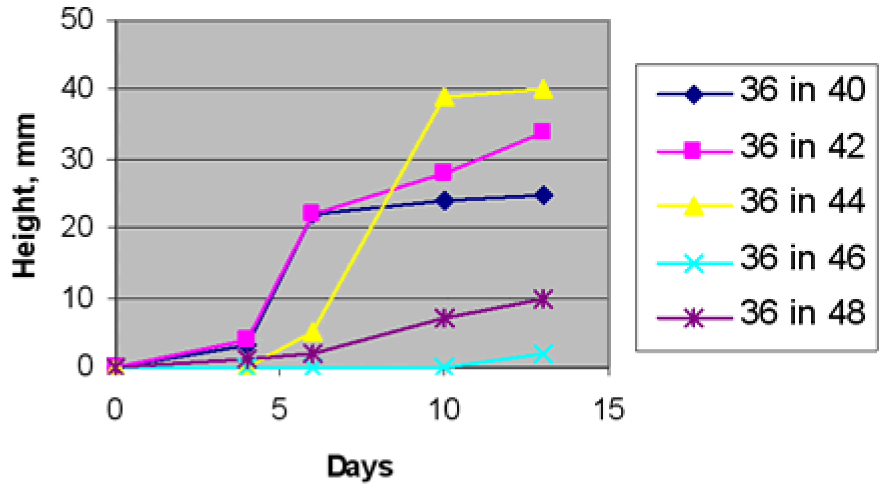

Figure 3: Gas volume produced by sample adapted to salinity 36 g/l at higher salinities

The microbes from the 36 g/l salinity tube appeared to be less successful (Figure 3) than those from the 40 g/l tube which showed better stability and adaptation (Figure 4). The lag period was 6 days. Gas production at the targeted salinity of 48 g/l was reached.

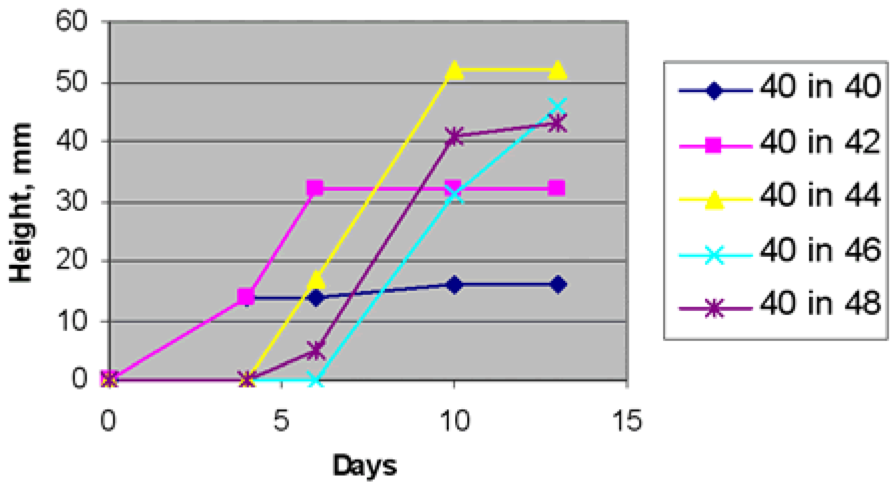

Figure 4: Gas volume produced by sample adapted to salinity 40 g/l at higher salinities

This procedure has demonstrated that it is feasible to increase the adaptation abilities of the microbes and select the best. The strain II pure culture demonstrated higher tolerance to salinity, so the adaptation process was easier. The samples of pure culture of strain II after adaptation to salinity 50 g/l were put in the salinities 40 g/l, 50 g/l, 60 g/l, 70 g/l and 80 g/l. They repeated good gas production at salinities of 40 g/l and 50 g/l but gave less gas production at 60 g/l and 70 g/l. The repeated run of these experiments will help microbes to be better adapted to salinity.

Conclusions

In general this experiment was carried out to see how microbes behave on a microscopic scale. It was observed that when inoculated in bigger bottles, the microbes show good activity at much higher salinities. However, to inoculate the microbes taken from bigger vessels, may not always lead to the same results.

The information gathered from this mini experiment will be useful in designing a standardised laboratory experiment to determine if the selected microbes will be successful in conditions similar to reservoir conditions.

Reference

1. M Wagner, *Microbial enhancement of oil recovery from carbonate reservoirs with complex formation characteristics, Kombinat Erdol-Erdgas Gommern, GDR, in Microbial Enhancement of Oil Recovery- Recent Advances,* edited by E.C. Donaldson, Elsevier Science Publishers BV, Amsterdam, 1997