New Technology for Improvement of Oil Quality

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Summary

Recent advances in microbial biotechnology have led to new applications for improving the characteristics of oil. The ability of specific microorganisms to produce a wide range of beneficial biochemicals has drawn new attention to the use of biochemicals versus chemicals for paraffin control, enhanced production, emulsion breaking, skin damage removal and the reduction in scale and corrosion. Microorganisms have the ability to colonize a formation and continually produce these desired biochemicals *in situ* for prolonged periods of time. Production *in situ* improves oil flow properties, removes occlusions from the formation pore channels, and releases oil trapped in the formation.

Crude oil samples from various geographic regions were collected and tested to measure the effectiveness of using biochemicals to improve the oil's characteristics. The report details the treatments and results and concludes that this technology appears to be applicable toward a broad spectrum of oil types and formations. Chevron Texaco is currently investigating a line of Biological products from Chevron Phillips Chemical Company to determine the scope of these applications.

Introduction

The field of microbial biotechnology has received increasing attention in the last decade and still holds a great deal of promise for oilfield applications. It has long been known that microorganisms have the ability to produce relatively high concentrations of solvents, surfactants, dispersants and enzymes to improve the characteristics of oil. But it is only recently that engineers have begun to learn how to exploit these abilities to outperform or augment traditional technologies including the use of oilfield chemicals. The fact that microorganisms can colonize oil/rock formations and generate a consistent production of beneficial biochemicals is one of the leading drivers in the exploration of new commercial products. The data and their respective claims will be presented in the following. The products are referenced under their trade name B-Chem 6.

Results

Viscosity and Pour Point Reduction

Tests were conducted on asphaltenic, paraffinic and non-paraffinic oils to determine the ability of the B-Chem 6 line to reduce viscosity and improve overall oil quality. When well head samples are referenced collections were done at a specified frequency throughout the monitoring process. During sampling a dedicated personnel was appointed to take samples as well as to conduct an on-site analysis to ensure consistency. To enable a reliable comparison pre-treatment samples were taken to provide a baseline. Samples were taken manually from the well head sampling port of each string. The samples were labeled, sealed in the appropriate containers and sent to the lab for analysis.

Well head samples from Southwest New York were compared after a 7-day treatment of this paraffinic oil (Figure 1). The pour point was reduced by 17° F and the cloud point was reduced from 4 °F to 5 °F. The cloud point is the temperature at which paraffins begin to crystallize and become solid. The solvents in B-Chem 6 act to degrade paraffin molecules by breaking the chemical bond between carbon atoms in the chain. Bonds are broken until the paraffin is no longer a solid and it becomes a mobile hexane (oil). Consistent results were seen in another paraffinic oil collected from the mid continent region (Figure 2).

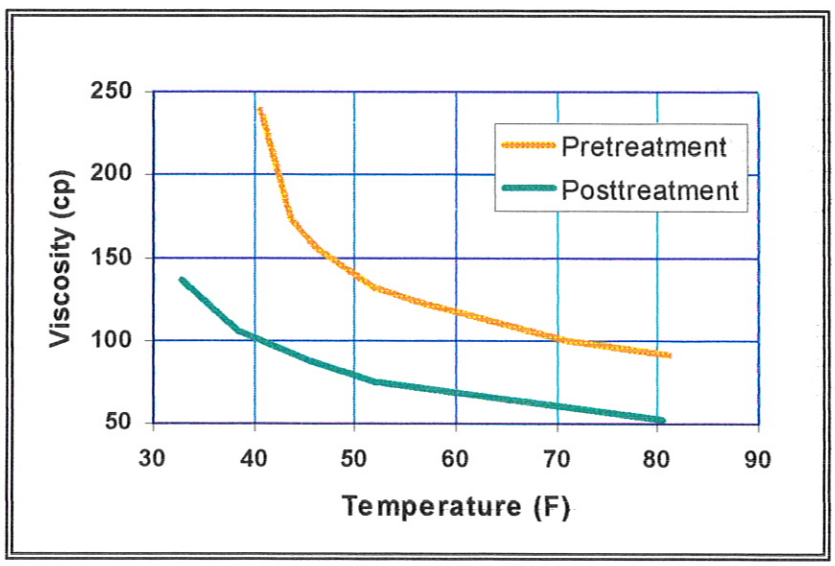
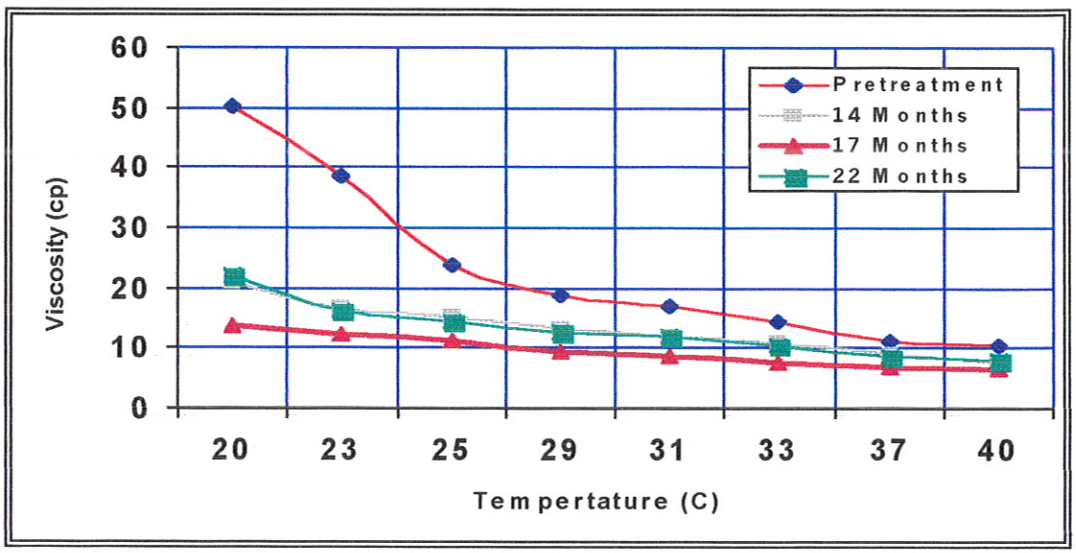


Figure 1



Tests on a non-paraffinic oil (API gravity 20 –25°) taken from the Tia Juana region of Venezeula exhibited a 41% decrease in viscosity after 2 months at 23° F.

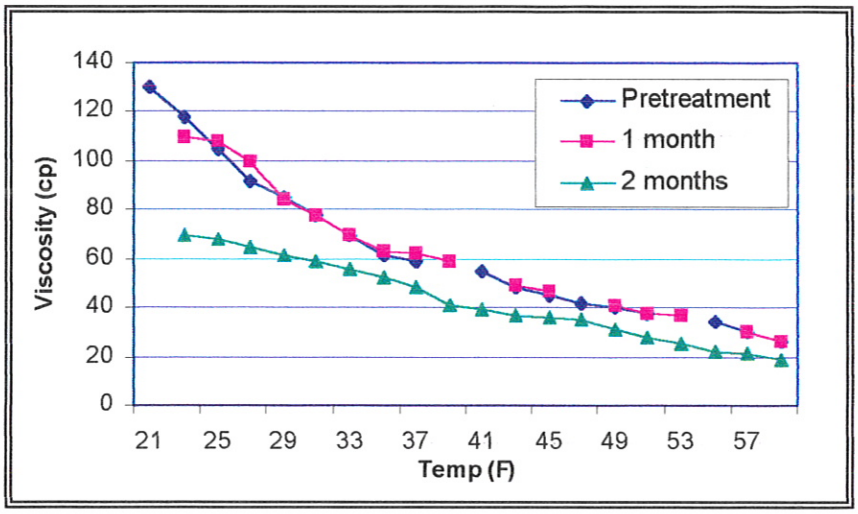


Figure 3

Oil from wells offshore Congo were producing a stable emulsion, which contributed significantly to viscosity. This was an asphaltenic heavy oil (~18 °API gravity) and after a one month treatment the pour point was measured and a substantial decrease in viscosity can be seen (Figure 4).

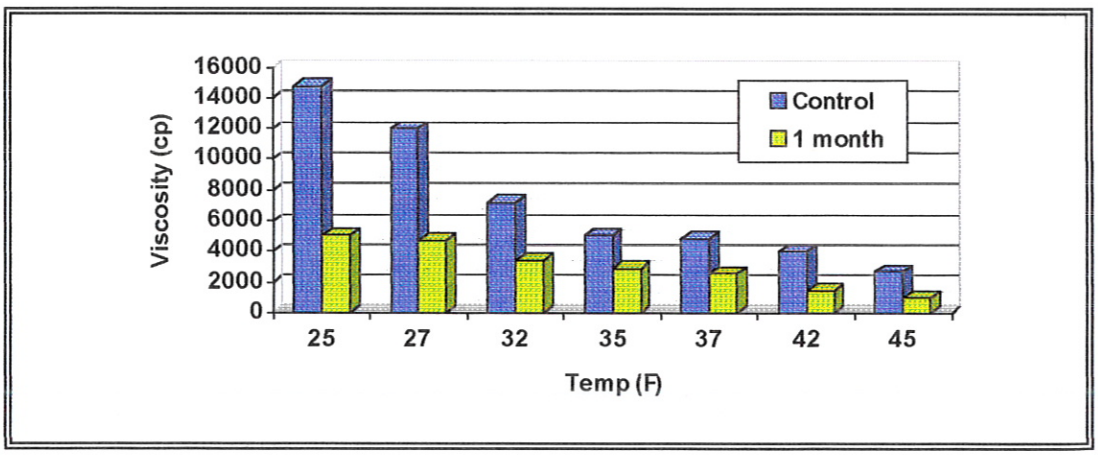


Figure 4

Increase in API Gravity and Degradation of Paraffins

Crude oil is composed of varying size carbon chain molecules. Depending on the size of the carbon chain, a hydrocarbon will either be a gas, a liquid (oil) or a solid (paraffin). For the purposes of these trials paraffin will be defined as pentane soluble hydrocarbon precipitates.

Increasing the lighter fractions (volatile compounds) will tend to increase the API gravity of oil and tend to reduce viscosity, thus increasing the oil's mobility and flow characteristics To evaluate this, laboratory analysis was performed on treated and untreated crude oil samples using gas chromatography (Figure 5). The samples were collected from Lake Maracaibo in Venezeula according to the aforementioned procedure. The results show a change in the distribution of alkanes and both a decrease in the long chain carbon paraffins and an increase in the lighter more valuable volatile fractions (lighter crude).

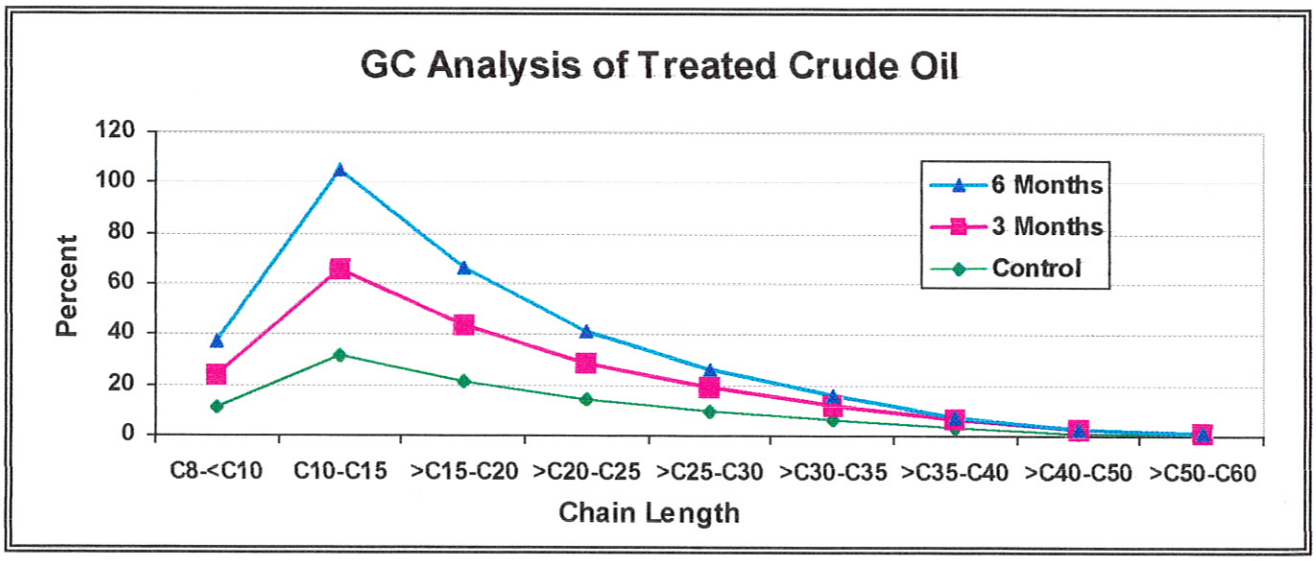


Figure 5

The API gravity was then measured on the same treated Lake Maracaibo oil samples (Figure 6). The action of the biochemicals in this treatment is most dramatic over the first month and then

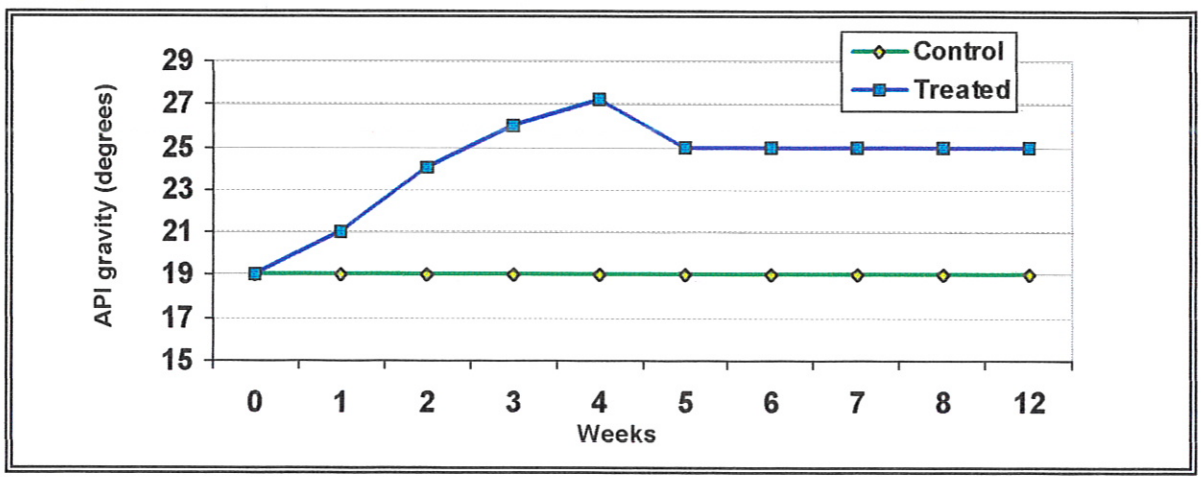


Figure 6

tends to level off over the next 2-3 months.

In a complete analysis on crude oil samples collected from the Uinta Basin duplicates of all samples were treated and the oil characteristics were measured after 7 days (Table 1).

Characteristic Measured	Control	Treated
API Gravity	39.4	41.9
Viscosity at 100 ° F	25 cp	15 cp
Viscosity at 210 ° F	15 cp	9 cp
Pour Point	98° F	81° F
Initial Boiling Point	196° F	118° F
End Point	602° F	636° F
% Residue (Paraffin)	60%	48%

Table 1

As expected, the API gravity increases and viscosity decreases.

Emulsion Breaking

The effects of B-Chem 6 to break oil/water emulsions were measured by treating samples with 10,000 ppm of product. The samples were then mixed and the height of the interface was measured over time (Figure 7).

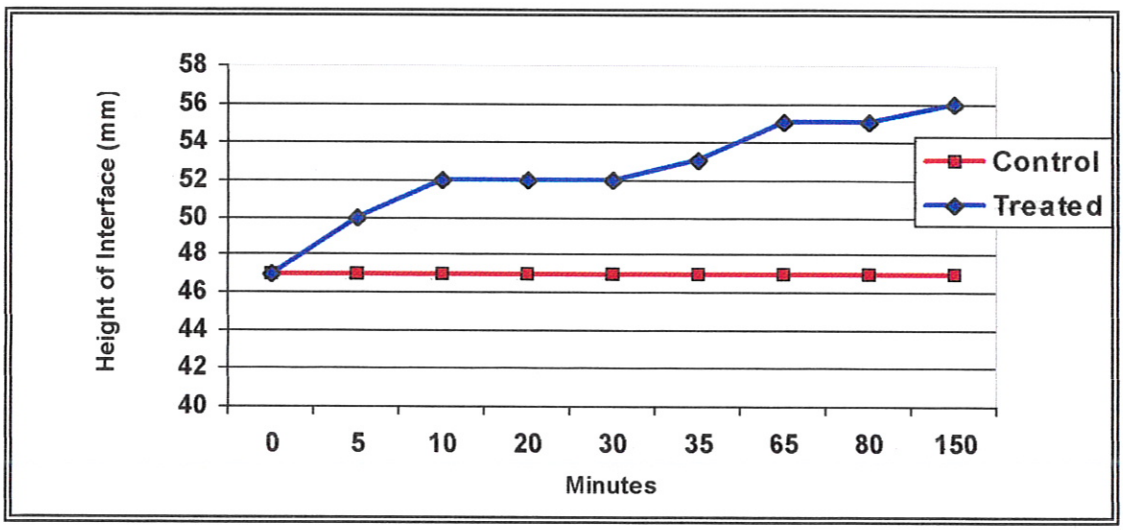


Figure 7

The production of biosurfactants and the ability of the microorganisms to grow in the water phase of the emulsion are the main reasons B-Chem 6 has been theorized to break emulsions. This process results in the coalescence of the water phase as the product acts as a bridging agent

between the water and oil phase. The surfactants that are produced then aid in the conversion of paraffinic waxes to lighter fractions which also reduces emulsion stability. This seems apparent in the above tests because the bridging action upon the emulsion is evident almost immediately.

Scale and Corrosion Control.

Observations that some of the biochemicals produced by microorganisms had properties similar to scale and corrosion control chemicals lead to the development of new B-Chem 6 product lines to address these oil field problems. The deposition of mineral scales in oil wells is a well-understood phenomenon. It is often related to the commingling of waters of different chemical types that produce a blend of ions that exceeds the solubility limit for compounds such as calcium carbonate, calcium sulfate or barium sulfate (to name the most commonly encountered oil field scales). Scale deposition can also be related to temperature and pressure changes occurring in the production string as the fluid column is brought to the surface.

Conventional chemical technologies utilize compounds that control scale through either chelation or dispersant mechanisms. Biochemicals such as organic acids are naturally occurring chelating agents that bind cations and thus restrict their capacity to form mineral deposits. Likewise, microbial biosurfactants such as rhamnose and trehalose glycolipids serve a similar function. Other microbial compounds act as filming agents, coating surfaces and preventing nucleation sites for scale growth from forming.

The ability to prevent scale growth *in vitro* is shown in Figures 8 and 9.

Untreated
Figure 8

Treated
Figure 9

These photomicrographs show how the growth of typical oilfield scale crystals in brine can be controlled by treatment with B-Chem 6S. In the trials above a solution of barium sulfate was treated and incubated for 24 hours. Photomicrographs were then taken against the control to compare the physical changes in the scale.

The mechanisms by which the products control scaling are chelation, crystal modification, and dispersion of scale nuclei. Filming activity of biosurfactants also prevents attachment of scale crystals to surfaces. Laboratory tests were conducted to determine the optimum concentration at which calcium carbonate precipitated out of crude oil using various concentrations of B-Chem 6. The turbidity was then measured (Figure 10).

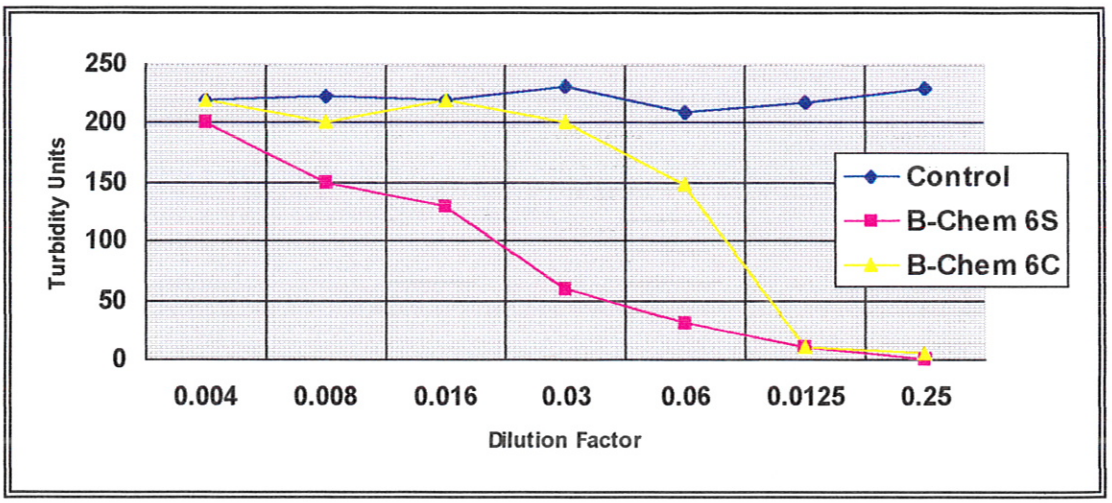
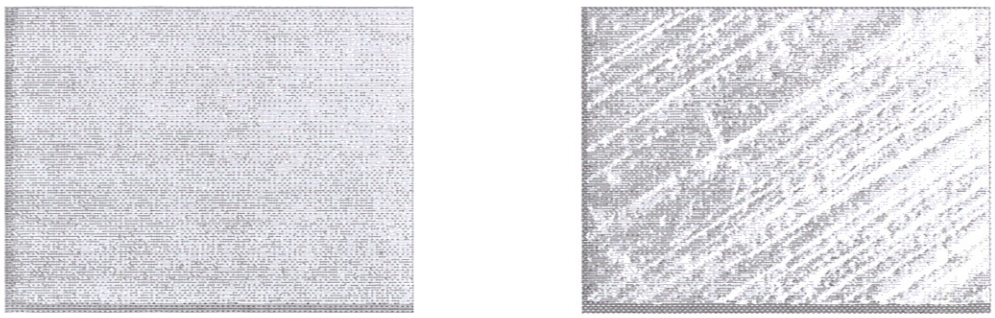


Figure 10

Such filming agents also act as passivating agents for controlling corrosion of metal surfaces. By coating surfaces, the interaction between corrosive compounds such as carbonic acids and sulfides is mitigated and corrosive processes reduced (Figure 11).



Untreated Solution

Treated Solution

Figure 11

In this trial steel coupons was immersed in a corrosive brine solution, one of which was treated with B-Chhem 6 and the other was left untreated as a control. After a 3 day period the surfaces were compared and photomicrographs were taken. The treated solution showed a surface free of corrosion and microorganisms could be observed binding and coating the surface.

Conclusions

The data presented here allow us to conclude the following:

The treatment of a diverse group of crude oil samples with B-Chem 6 resulted in a significant compositional change in hydrocarbon distribution with a shift from long chain paraffins to lighter chain volatiles. The physical changes that can be measured from this hydrocarbon shift are a reduction in viscosity and pour point and an increase in API gravity and solvent composition.

The expansion of microbial biotechnology for the enhanced production of novel biochemicals merits further exploration and should be incorporated into a mainstream technology.

The use of biochemicals has many advantages over conventional mass chemical treatment in that chemicals depend totally on the movement of fluids through the oil fields as the only means of transportation. Microorganisms, on the other hand, target the site and have the ability to mobilize themselves through the formation where problems occur before beginning biochemical production. The biochemicals are then targeted to the site of the problem in a on-going production resulting in longer term benefits.

The biochemicals produced are also much more widespread allowing not only the treatment of the desired symptoms but a greater improvement in the overall quality of the oil in the formation.