ENHANCED OIL RECOVERY

INTERFACIAL ANALYSIS FOR OPTIMIZING TERTIARY RECOVERY METHODS

KRÜSS

Advancing your Surface Science

OPTIMIZATION OF EMULSIONS AND FOAMS IN TERTIARY OIL RECOVERY

- **Enhancement of emulsion formation during chemical flooding**
- **Improvement of oil detachment from reservoir rock**
- **Use of foams in gas or steam recovery**

Conventional methods of oil recovery exploit between 20 to 40% of the oil enclosed in the reservoir rock. Methods used in tertiary or enhanced oil recovery (EOR), such as liquid, gas or steam flooding, can extract significant, additional amounts of the residual oil left in the rock. When applying these methods, surfactants play a key role. During chemical flooding they help form emulsions between the aqueous flooding solution and the hydrophobic oil phase and improve the separation of the oil from the rock. Flooding with gases or steam is often aided by foam-forming surfactants in order to achieve uniform penetration of the oleaginous rock. Interfacial chemical analysis can boost the efficiency of these EOR procedures and can be decisive for their profitability.

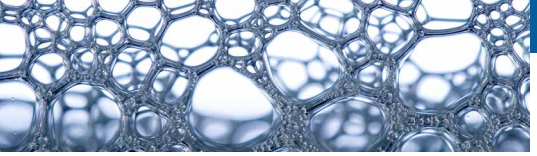
In chemical flooding, surfactants help mobilize oil by forming emulsions

During flooding with liquids, a complex mixture of alkaline bases, polymers and surfactants is injected into the reservoir. The surfactants reduce the interfacial tension (IFT) between the flooding solution and the oil, thus improving mobilization of the oil through the aqueous phase. Ideally, the IFT is reduced to such a degree that a microemulsion forms, which is a homogenous and long-term stable mixture whose components do not separate again while flowing through the rock. Whether or not such an emulsion forms depends not only on the nature and concentration of the surfactant, but also on the salt content and temperature of the reservoir water. The IFT often drops by several decades in the vicinity of the frequently tight concentration and temperature range for the formation of a microemulsion. Measurements of the IFT using the spinning drop method, which is specialized in the determination of extremely low IFT values, is an ideal method for optimizing flooding mixtures.

Lowering the flooding solution's surface tension improves oil separation from the rock

Oil has a lower surface tension (SFT) than water. This means that oil wets the porous rock better than water and so does not readily separate from it. In addition to their emulsifying effects, surfactants lower the SFT of the flooding solution and improve its wetting of the rock, thus facilitating mobilization of the oil.

In order to analyze the wettability of the rock by oil or water, the contact angle can be measured. This shows the shape of a drop on a solid surface. The better the wetting, the flatter the drop and the smaller the contact angle. For this reason the contact angle of the flooding solution can be used a criterion for its optimization.



In gas flooding, foams increase the oil yield

Gases such as carbon dioxide, nitrogen or steam are used as an alternative to chemical flooding with liquids. Gas flooding processes are often enhanced by the use of foam-forming surfactant solutions. The gas is bound in the foam, thus reducing the volume of gas required while the achieved viscosity increase results in improved flow control. In addition, the "gas override" effect, whereby the gas flows above the oil-bearing strata due to its lower density, can be prevented by foam. The absorbed foam lamellae act here as a seal in the higher layers of the rock allowing the conveying gas to flow through the oil-bearing strata, thus increasing the oil yield.

The foams used must be stable mechanically and over time

EOR technologies place special demands on the stability and structure of the foam. In respect to liquid content, the foam should bind as much gas as possible. At the same time high mechanical stability is required of the foam, as its lamellae are severely deformed when they flow through the porous rock. Due to the often long flow distances and correspondingly long retention periods, the foam must also be stable in the long term. This requires foam that is homogenous and has a narrow bubble size distribution.

All these properties of a foam needed to ensure a good oil yield can be determined using scientific foam analyses. Foam height measurements enable conclusions to be drawn about the foamability and foam stability; liquid content is determined by conductivity measurements while foam structure analyses indicate bubble size and its distribution. In addition interfacial rheological analyses can be used to examine the mechanical stability of the lamellae.

Analyses undertaken under reservoir conditions help optimize recovery methods

As a rule high pressures and temperatures are present in the reservoir and these affect all the aspects of surfactant use described above – interfacial tension, wetting and foam properties. There are a number of solutions for interfacial chemical analysis and issues that allow measurements to be made under reservoir conditions. These enable especially application-orientated optimization of the surfactants and, their concentrations as well as other process parameters in order to ensure the greatest possible recovery yield.

MEASURING METHODS

A number of analytical methods serve as an aid in the optimization of flooding mixtures and foams for EOR:

- Measurement of the IFT with the spinning drop method
- Measurement of the SFT and IFT using the pendant drop method under standard or reservoir conditions
- Measurement of contact angle on rock under standard or reservoir conditions
- Analysis of the stability and structure of liquid foams under standard conditions as well as high pressure and temperature
- Measurement of interfacial elasticity in order to assess emulsion and foam stability using the oscillating drop method

KNOW-HOW FOR YOUR APPLICATION

If you would like more detailed information about your application, just get in touch with us. Our scientifically trained customer representatives have excellent knowledge of interfacial chemistry and process technology and share their expertise – comprehensively and competently.

We would also be happy to assist you with professional contract analyses from our laboratories. In addition, we provide scientific application reports on various topics which cover specific issues in research, development and quality assurance. With offers like these, we pass on a great deal of know-how for your application.

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