

Application of surfactant in oilfield development

Shizhang Cui, Pengzhen Wang, Zhiwei Zheng, Xu Zhang

Deshi Energy Technology Group CO.LTD, Shangdong, PR China Summary

Abstract. With the rapid growth of the global economy, China's economy is also rapid development, and the demand for crude oil in various countries is geometric multiple growth, domestic demand far exceeds the progress of domestic mining. The security of the domestic economy will suffer as crude oil prices rise. The increase of mining rate should be strengthened on the domestic baseline, using physical, biological and chemical technology support, three mining. The recovery of crude oil was increased to 80.0%-85.0% with high-dose polymer and surfactant.

1. Preface

On August 20, 2018, at the 2018 National Oil Field Chemical Development and Application Seminar, it was pointed out that the salt and temperature resistance of surfactants and water-soluble polymers had a great influence on drilling fluid and crude oil extraction. Surfactants and water-soluble polymers are widely used in oilfield drilling and oil recovery. In oil field drilling and exploitation, the purpose of drilling, oil recovery and oil displacement is mainly achieved by using the low tension of surfactant and the viscosity of polymer. Xin Yinchang said this is because surfactants can greatly reduce the surface tension of water, do not increase the viscosity of water, and water-soluble polymers can greatly increase the viscosity of water. If there is no surfactant, there is no clean us. Surfactant molecules combine the ordered combinations of molecules in solution and interface to form various important processes, such as wetting, packaging, playing an important role in foam, oil painting, household use, dispersion, cleaning, improving the quality of life of the general public through the process of re-synthesis and purification of surfactants, and taking a step forward in human and scientific standards.

2. Introduction of surfactants

surface tension is significantly reduced even at very low concentrations of surfactants. As we all know, surfactant applications are regulated and can not be mixed casually. Surfactants are a class of substances that can significantly reduce surface tension even at very low concentrations. With the development of surfactant research, it is generally believed that substances which can significantly change the surface properties or related properties at lower concentrations can be classified as surfactants.

Surfactants are natural, Like phospholipids, choline, proteins, But more synthetic, such as sodium octadecyl sulfate $C_{18}H_{37}NaO_4S$, sodium stearate $C_{17}H_{35}COONa$ etc. A wide range of surfactants (cationic, anionic, nonionic and amphoteric), To provide a variety of functions for specific applications, Including foaming effects, Surface modification, Clean, Emulsion, Rheology, a series of physical and chemical actions and corresponding practical applications such as environmental and health protection, Flexible, A wide range of precision chemical products, China's surfactant industry has developed rapidly in recent years, In 2005, the country's main production enterprises surface active.



My total output (without soap) is at least 1.15 million tons. Of which, A-S still dominates, accounting for 74.9% of the total. N-SEA 22.7%, c-AA 1.6%, S-A 0.8 per cent.

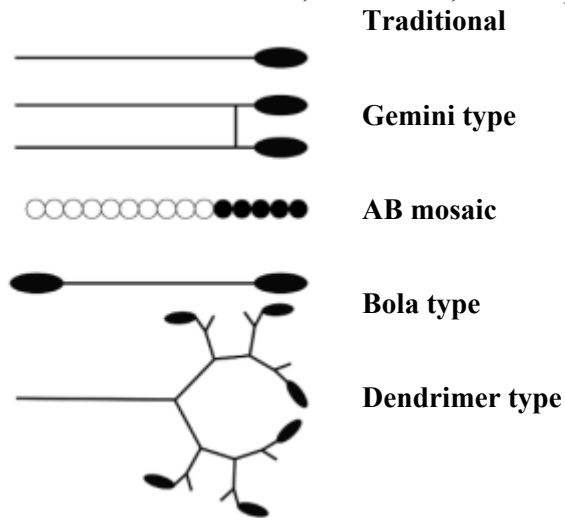
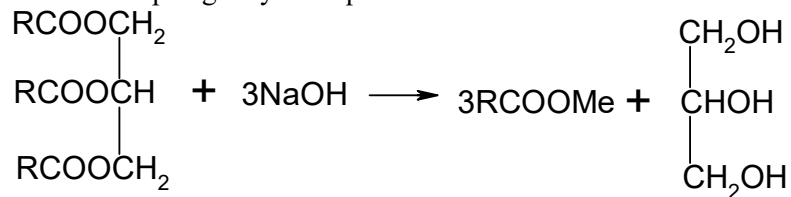


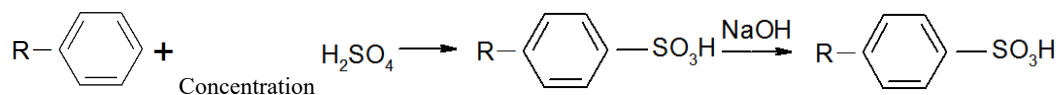
Figure 1 Schematic diagram of surfactant structure

3. Synthesis of surfactants

(1) Soap: Heat the water vapor of oil and alkali of natural animals and plants in a gas-liquid manner, causing the reaction of the soap angle by the equation:

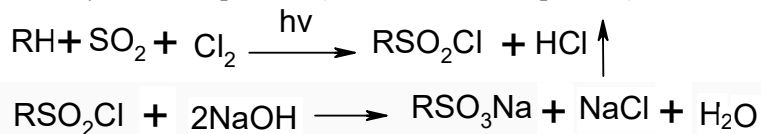


(2) alkylbenzene sulfonate

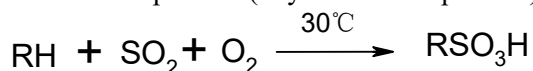


(3) alkyl sulfonate

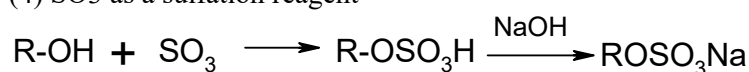
Sulfonyl chloride process (chlorosulfonation process)

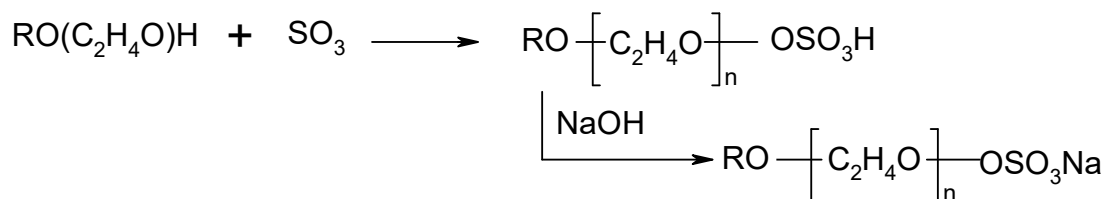


Sulfonation process (oxysulfonation process)

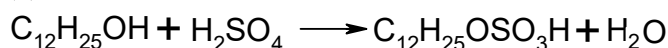


(4) SO₃ as a sulfation reagent

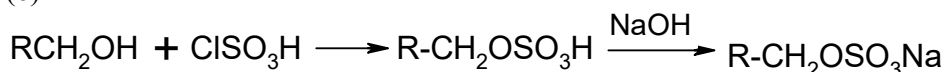




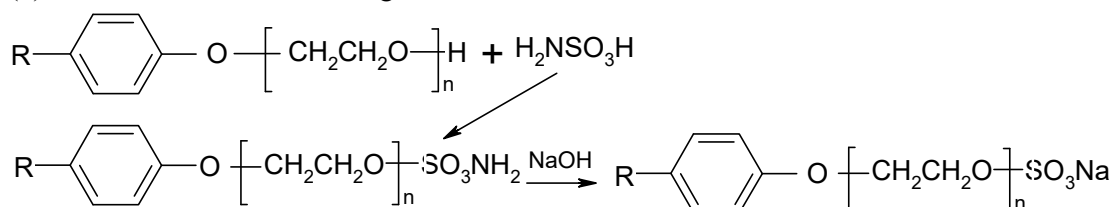
(5) Concentrated H₂SO₄ sulfated



(6) Sulfonic acid sulfation



(7) Aminosulfonic sulfation reagent



It is great to sum up the use value and theoretical significance of this molecule, which is all over every corner of people's daily life and is closely related to us. During the 20th century, the molecule already had a complete gene range rather than a hydrophobic gene of a polar hydrocarbon chain. Although the hydrophobic group of a nonpolar group is like this, it can not deny its characteristics such as the hydrocarbon chain is more than 8 C atoms. Humans have charged hydrophilic groups, anionic, nonionic and amphoteric surfactants classified into four categories. Not readily available, covering many compounds.

4. Application of Surfactant in Petroleum Exploitation

Oil has always been the highest. In the past few years, the exploration, development and excavation costs of oil are increasing year by year. In the process of oil field development, the method of exploitation plays a key role in improving the production capacity of oil field. It is very important to select effective mining methods for oil reservoirs with different properties and geological characteristics. In China, some oil fields have been developed for a long time and entered into the middle and late stage of oil field development.

4.1 Chemical agents for new oil flooding

In order to change the present situation in China, Daqing and Shengli oil fields fully exploit underground oil, strengthen the research on crude oil extraction technology, develop new crude oil, and achieve good results.

4.2 Polymer flooding

Polymer flooding is an oil flooding method using polymer solution as oil displacement agent, which appears in the experimental results of Daqing Oilfield. when the effect of general polymer surfactant put into water is satisfactory, it will be better to replace general polymer and alkali/surfactant into water. in order to improve the viscosity of water in oilfield development, polymer can be injected into water. This can reduce the water molecular dialysis rate of oil layer, improve the ratio of oil to water, adjust the fluctuation probability and volume of crude oil, improve the extraction rate of crude oil. The mechanism of polymer flooding is to add polymer into the injected water, increase the viscosity of the

displacement phase, adjust the water absorption profile, increase the wave volume of the displacement phase, and thus increase the final oil recovery.

4.3 Microbial oil recovery

Microbial oil recovery technology includes not only the biochemical processes of microbial growth, reproduction and metabolism in the oil layer, but also the migration of microbial bacteria, microbial nutrient solution, microbial metabolites in the oil layer, and the changes of rock, oil, gas and water properties caused by the interaction with rock, oil, gas and water. In a broad sense, the basic methods of microbial oil recovery include two categories, one is the use of microbial products as oil field chemicals for oil flooding, called biological process method; the other is the use of microbial underground fermentation and metabolites to improve oil recovery, called microbial underground fermentation to improve oil recovery method. The narrow understanding of microbial oil recovery refers to the use of microbial underground fermentation to improve oil recovery methods.

4.4 Microbial oil flooding

Microorganisms can grow in reservoirs or on the ground. In surface culture, microbial metabolites can be isolated and collected, processed and then injected into the reservoir.

From a professional point of view, microbial flooding is somewhat similar to underground biological transformation. the injected nutrients, together with native or exogenous microorganisms, promote the growth of underground microorganisms and metabolites, allowing more crude oil to flow, increasing residual oil mobility through reservoir depressurization, interfacial tension/oil phase viscosity reduction, and selective blockage of hyperosmotic areas. In addition, the active microorganism injected into the reservoir after fermentation can also achieve the effect of increasing production. Microorganisms must not only produce the chemicals necessary for the flow of crude oil, but also reproduce and grow in reservoir environment. In the process of microbial oil flooding, nutrients are often injected to maintain microbial metabolism, and sometimes fermentable carbohydrates are injected into reservoirs as carbon sources. Some reservoirs also require inorganic nutrients as the base fluid for cell growth or as another electron receptor for aerobic respiration.

microbial engineering to improve the oil recovery rate of crude oil, we divided it into two main types: one is to inject the bacterial metabolites into the oil layer, and use the composition of biosurfactant, biological polymer, solvent, emulsifier, etc., to drain water out of the oil and improve the performance. The second is to target the development of micro-organisms-bacteria metabolism and remove oily. given that exploitation suitable for microbial development is not suitable for new oil fields. The addition of fresh water to the oil around the bottom of the well by the formation of characteristic bacterial metabolites can improve the development of new oil fields in the process of exploitation; through the development of microorganisms to improve the extraction rate of oil fields.

- (1) Changing the wettability of heavy hydrocarbon components;
- (2) In order to reduce the viscosity of crude oil, long chain saturation is solved;
- (3) Increasing the acidity used to dissolve the rock mass is a certain permeability;
- (4) Reducing the viscosity gas of crude oil and enhancing reservoir pressure.

Oil recovery company is an oil field in the process of mining, using a variety of surfactants to improve their own collection efficiency, improve the utilization rate of oil to a grade, in the third crude oil mining, surfactant theory and practice should also be studied, but also to study the interfacial active agent and three crude oil extraction method in the prospect of petroleum chemistry development prospects.

4.5 Ternary composite flooding technology

adsorption at the oil-water interface to reduce the oil-water interfacial tension and improve the oil washing ability. So that oil and water emulsification, emulsification carrying and emulsification to expand the wave volume, improve oil recovery. Adsorption on the rock surface, although changing the

wettability of the rock is beneficial to improve the recovery, the adsorption loss leads to the increase of the amount of surfactant,

According to the experimental results of interfacial tension and capillary number, oil displacement efficiency and residual oil saturation, and the calculation results of Daqing oil field geological conditions and driving system, it can be concluded that only when the oil-water interfacial tension reaches 10-3 mN/m orders of magnitude, the residual oil can be started. interfacial tension between ternary composite system and Daqing crude oil must reach 10-3 mN/m orders of magnitude.

4.6 Surfactant and tertiary oil recovery

In the era of rapid development of social economy, large-scale oil fields in China have developed new development technology for oil field export because of insufficient development due to technical defects. With the oil well exploitation, the pressure decreases, and the crude oil in the deep strata is not easy to be extracted.

The third oil recovery means that after the primary oil recovery depends on the original energy of the reservoir and the secondary oil recovery is replenished by water injection, the physical and chemical methods are adopted to change the nature, phase state of the fluid and the interface between gas-liquid, liquid-liquid, liquid-solid phases, and to expand the spread range of the injection of human water to improve the efficiency of oil displacement, so as to increase the oil recovery greatly again.

By injecting a certain concentration of acid into the oil well, it can react with the formation rock, increase the formation permeability, improve the oil flow channel, and achieve the purpose of oil well production. So far, Daqing Oilfield has achieved remarkable results in ternary complex. The combined production rate of tertiary oil recovery technology is 20%, which greatly improves the production rate.

5. Types of surfactants

There are many kinds of surfactants, and there are many classification methods, such as according to the use of surfactants can be divided into wetting agent, osmotic agent, emulsifier, dispersant, softener, antistatic agent, detergent and so on. It is common to classify surfactants into anions, cations, zwitterions and non-ions according to their ionization characteristics in aqueous solution.

I. Anionic surfactants

Some negatively charged surfactants that are active after ionization in water are called anionic surfactants. The anionic surfactants are structurally classified into four categories: fatty acid salt, sulfonate salt, sulfate salt and phosphate salt.

II. Cationic surfactants

the surface active ions generated by cationic surfactants when ionized in aqueous solution are positively charged, and their hydrophobic groups are similar to anionic surfactants. The hydrophilic ions of cationic surfactants contain nitrogen atoms, which can be divided into amine salt, quaternary ammonium salt and heterocyclic type according to the position of nitrogen atoms in molecules.

III. Gender surfactants

Usually, the surfactant containing both positive and anionic in hydrophilic structure is called amphoteric surfactant. It mainly includes imidazoline type and amino acid type.

IV. Nonionic surfactants

Nonionic surfactants are second only to anionic surfactants in quantity, mainly including polyoxyethylene type, polyol type, alkyl alcohol amide type. Specific can also be subdivided into many categories, can refer to the relevant surfactant books!

5.1 Solubility of surfactants

we already know that the surfactant function is very strong, which can be summed up from two aspects. first, the surfactant is adsorbed from the surface or interface to form a layer of molecular adsorption film. second, the internal part is constantly recombined in the solution to form different kinds of orderly molecular assemblages. such as adhesive, foam, liquid crystal, etc. this orderly molecular assemblage has different functions, and adhesives play a very important role here. based on

surfactants, hydrocarbons and long chains can clearly increase the utilization rate through adhesives of insoluble or water-soluble substances such as hydrocarbons and long chains. Based on the function of expanding the capacity of adhesive and other order molecular combinations, the catalyst of adhesive stage is derived to form the functions of micro cream liquid, interactive reaction media and aesthetic reaction media, drug carrier and so on.

5.2 Salt-tolerant surfactants

The times are progressing, the technology is developing, the depth of the oil field is rising, the salt and temperature of the formation are rising, and the requirements for technology have been raised a lot. Although salt-resistant surfactants are scarce, salt-resistant polymer compounds are on the scene in large quantities, and the category is gradually increasing.

In the third stage of oil recovery technology, mainly petroleum sulfonate surfactants are widely used. Petroleum sulfonate has a wide supply of raw materials, oil production, good coordination with crude oil, relatively simple manufacturing process, low cost, more ideal oil surfactant but the chemical composition of this surfactant is complex, containing hundreds of compounds, so the oil discharge effect is very large. For example, the cultivation system of alkyl polyoxyethylene sulfate and petroleum sulfonate and the mixed system of carboxymethyl non-ion positive surfactant and petroleum sulfonate can significantly improve the anti-inflammatory property of the system, the former has relatively excellent calcium resistance, and the latter can obtain ultra-low surface tension to suit the formation with high salinity without adding low molecular weight alcohol.

mixing a variety of surfactants can improve the overall salt durability, such as the main surfactant of the known aromatic sulfonate, the carboxymethyl acetate compound and the sodium hydroxide salt, which can make the surfactant, the inflammation resistance of the mixture. with significant improvement. a mixture of olefin hydrochloride and sulfonate diphenyl ether sulfonate can improve the water extraction rate, enhance the tolerance to flow control and Ca^{2+} , and reduce the adsorption rate of the reservoir. the double-sided active agent system composed of base sulfonate and ether sulfonate has high branching efficiency, and the interchangeability with denatured polyacrylamide polymers is prominent, which is especially suitable for storing high concentrations of oil.

5.3 Temperature resistance of surfactant

Because the properties of surfactants are greatly affected by temperature, how to solve this problem should be considered in the manufacture of chemical synthetic surfactants. among these introduced multiple surfactants, nonionic surfactants are able to improve this problem. contains a large amount of ethylene oxide or propylene oxide composition, the cloud point of this element generally reaches 80-110°C, the temperature and cloud point will dissolve in the lower solution, and a large number of a few components will dissolve in the oil and gas temperature or high oil recovery will also be increased.

6. Surfactants for oil flooding

The addition of surfactant can reduce the interfacial tension between oil and water, promote emulsification, reduce the solubility of oil and water, increase the rock absorption of crude oil and reduce the viscosity of crude oil. Generally speaking, the surfactant picked by crude oil is greatly increased.

- (1) The use of interfacial tension between crude oil and water was reduced to a minimum, about 0.01~0.001 mN/m below, due to the compatibility of solubility, pH value, cloud point, etc.;
- (2) The adsorption of crude oil by rock strata can be reduced;
- (3) To maintain reasonable stability in the brine of the oil layer for a long time at the temperature of the petroleum rock layer, and to be salt tolerant and insensitive to the electrolyte;
- (4) Exposure to most of the oil layers can increase oil emission rates;
- (5) High economic value.

The characteristics of surfactant itself is one of the factors that affect the oil discharge effect, so what are the many factors that affect the oil discharge effect of surfactant? For example, because the anion has a strong suction between the two, the two are close to the surface of crude oil, separating the oil interface and reducing the tension of the oil interface. The nonionic interfacial active agent has good solubility, high stability, strong electricity, inorganic salt, acid and no alkali influence in water and organic solvent, and it has good compatibility with other kinds of surfactants. lactic acid polyoxyethylene ester, etc. The addition of surfactant in tertiary oil recovery is not only one, but a composite system composed of a variety of surfactants, polymers and auxiliaries. Only mutual assistance can increase oil extraction rates. Surfactants are added to tertiary oil production because they are not just one, there are many kinds of active agents, and the efficiency of mining is improved rapidly to a greater extent.

7. Conclusion

As a kind of auxiliary chemistry of the third oil recovery technology, surfactant is a polymer, which plays an indispensable role in the third oil recovery technology, such as ternary composite screwdriver. By using this chemical trend, the oil recovery rate of crude oil can be increased by 10~20%, which effectively alleviates some burden of domestic crude oil. Surface activity, polymer, ternary composite mechanism and other chemical institutions will be a wide range of raw materials, low-cost, high-performance era is not far away. will effectively reduce the cost of oil extraction. The Research and Application of Surfactant System for Enhanced Oil Recovery in Offshore Oilfield. Major Science and Technology Innovation Project of Shandong Province (2019JZZY010354).

Acknowledgement

The Research and Application of Surfactant System for Enhanced Oil Recovery in Offshore Oilfield. Major Science and Technology Innovation Project of Shandong Province (2019JZZY010354).

References

- [1] Xu Xingxi. Application and Innovation of Anionic Surfactant [J.] Chinese washing products industry. 2012(08) Application of cationic surfactants (Baidu library)
- [2] Fang Yun, Xia Yongmei. Application of amphoteric surfactants [J.] Daily chemical industry. 2001(03)
- [3] Liu he. Characteristics and Application of Nonionic Surfactants [J.] Leather and chemical. 2012(02)
- [4] Zhao Fulin. Oil recovery agents. Dongying, Shandong: Petroleum University Press
- [5] Wang Zhonghua; Present Situation and Development Trend of Surfactant for Oilfield [J]; Henan Chemical Industry ;2006-01
- [6] Guo Donghong, Xin Haochuan, Cui Xiaodong, Zhang Yaqin; Study on interfacial tension properties of surfactant pilot-scale products used in Daqing crude oil [J]; progress of fine petrochemical industry ;06 issue 2003

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.