E3S Web of Conferences **338**, 01009 (2022) https://doi.org/10.1051/e3sconf/202233801009
ESMA 2021

Performance evaluation of temperature-resistant nano-surfactants

Qunyi Wang [1], Yongbin Bi [1, 2], Tongfeng Cao [1], Yang Zhang [1], Dong Liu [1], Haiyan He [1], Xuena Zhang [1]

[1] Jidong Oilfield Company, PETROCHINA, China
[2] Northeast Petroleum University, China

Abstract. Surfactant flooding is a common technique in tertiary oil recovery. However, due to the high temperature of some reservoirs and the strong heterogeneity caused by their own geological conditions, the use of common surfactants in high-temperature reservoirs is limited. Temperature - resistant surfactants can reduce interfacial tension, improve conformance and increase oil washing efficiency In this paper, a temperature-resistant nano-type surface active JCN-001 was developed in the laboratory. By testing its particle size distribution, the experimental results can determine that the average particle size range of the system is 34.29nm, so that it can play a better role in low permeability reservoir recovery. Due to its unique nano properties, JCN at 0.2% concentration can still maintain a good effect at about 110, and the oil/water interfacial tension can reach 10-4nm /m, and can also reach ultra-low interfacial tension at high temperature, and the higher the temperature, the more significant the effect According to the changes of surface tension and oil-water interfacial tension, the critical micelle concentration was determined to be about 0.2%. The static adsorption experiments and dynamic adsorption experiments were carried out. The results show that the temperature resistant nano-surfactants have strong adsorption resistance and can effectively reduce the consumption of surfactants on rocks.

Key words: nanoparticles; Interfacial tension; Temperature resistant surface active agent; Enhanced oil recovery.

1. Introduction

As the conventional oil field has gradually entered the later period, the high temperature and other special oil and gas field development is increasingly wide attention by the researchers both at home and abroad. For example, shengli oilfield Jidong oilfield The hydrocarbon resources in tarim oilfield, such as the typical high temperature block is also considerable, because of its special geological conditions of reservoir itself, strong heterogeneity, reservoir temperature higher than 100 [1]. The effect of ordinary surfactants and polymers is not obvious under the condition of high temperature, and in the development process of water cone oil field, water cut rises fast and single-layer sudden phenomenon, serious uneven reserve utilization [2]. The function of nanomaterials provides a new perspective for the development of increasingly miniaturization and complex technology [3]. In recent years, surfactants have been widely used in the preparation and surface modification of composite nanomaterials and nanoparticles of different morphologies and sizes [4]. In order to realize the functionalization of nanomaterials Nano SiO2 exist a lot of surface, surface hydroxyl in the alkaline medium dissociative will happen so that SiO2 nanoparticles surface is negatively charged, and cationic surfactants hydrophilic head baseband has a positive charge [5]. Both can be spontaneously through the electrostatic force is united in wedlock, form large aggregates, the viscosity of the solution surface activity produces change [6], etc A kind of temperature resistant nano surfactant was developed by combining functional nanotechnology with surfactant, which can provide theoretical guidance for laboratory and field [7]. Ption to develop a reasonable development adjustment plan for complex block oil fields [8].

2. Experiments and methods

2.1 Materials and instruments

PDES/ODES negative - non-ionic surfactants; Nano silica SiO2 average particle size 155nm purity 99%; The experimental water is used to provide formation water for oilfield field, and the high speed mixer with a salinity of 2329mg/L. High temperature and high pressure aging reactor; Laser particle size analyzer; CNG interface tensiometer; Shz-22 Water bath constant temperature oscillator (Shanghai); Ld4-2 electric centrifuge (Jiangsu);

Wcj-801 temperature-controlled magnetic agitator (Jiangsu); METTLER -PM200 1000 - Electronic balances (Switzerland) and different conventional glassware.

2.2 Particle size distribution

A temperature-resistant nano-surfactant with a concentration of 0.2% was prepared and synthesized in the laboratory. It was named JCN-001 and its particle size distribution was determined. Laser particle size analyzer was used in the experiment First, the sample container was cleaned, washed three times with anhydrated ethanol and then washed three times with the liquid to be tested. After cleaning, the liquid to be tested was dropped into the container to determine the particle size distribution. Experimental results showed that the average particle size of JCN-001 was 34.29nm, and the experimental results showed good dispersion as shown in the figure below.

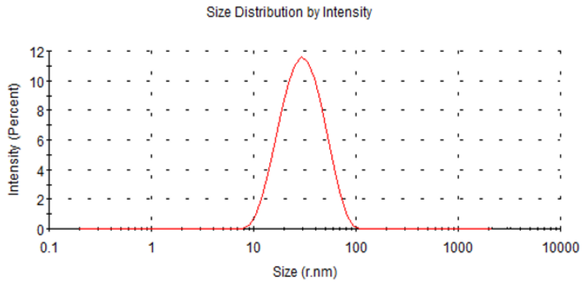

Figure 1. Particle size distribution of JCN-001 at 0.2% concentration

2.3 Measurement of oil-water interfacial tension

Interfacial tension (IFT) is a key parameter to measure the oil washing efficiency of foaming agents. In the order of 10-3Mn /m, it is considered to be an ultra-low grade [8]. At this time, the number of capillary tubes can be greatly increased and the oil displacement effect can be changed. Commonly used measurement methods include ring removal method, hanging plate method, rotary drop method and so on[9] .Under the action of centrifugal force and interfacial tension, the oil droplets suspended in aqueous solution are pulled into cylindrical shape. The shape is determined by the interfacial tension, and the shape is easy to be measured at equilibrium. Therefore, this method is convenient to measure the ultra-low interfacial tension [10].

Experimental steps:

1) Preparation of 0.2% jCN-0001 and common alkylbenzene sulfonate surfactant A;

2) Turn on the power source of CNG interfacial tension instrument and adjust the equipment temperature to 110 for preheating;

3) Moisten the sample tube once with the liquid to be tested, and then fill the sample tube;

4) Draw the crude oil provided by the site with a syringe, tilt the sample tube downward at a certain Angle, inject a small drop of crude oil into the sample tube to remove the small bubbles in the sample tube, button the tube cap, and install the sample tube into the rotary cylinder of the interface tensionometer for preheating for 5min;

5) Adjust the speed to 5000rpm and move the camera of the interface tension-meter to make the oil droplets move to the center of the screen for experimental observation;

(6) Start the interface tensionometer and calculate the instantaneous interfacial tension value through the program every 5min;

7) The measured data were plotted, and the lowest point was denoted as the lowest value of instantaneous interfacial tension.

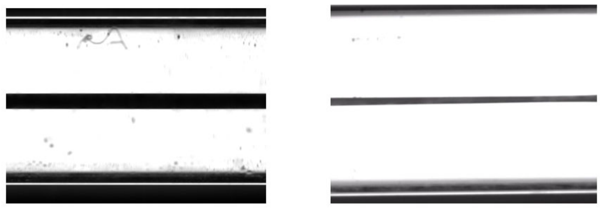

Figure 2. Oil-water interface tensile diagram of ordinary surfactant and nano-JCN-001 (temperature-resistant nano-surfactant at the back)

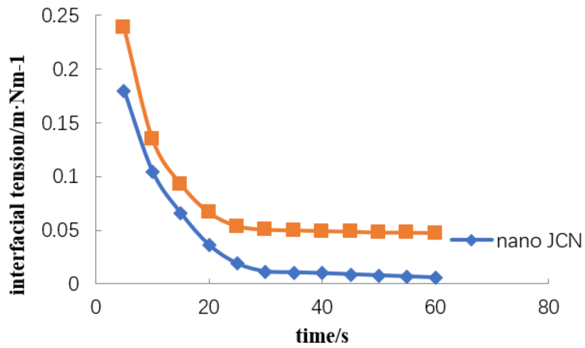

Figure 3. The oil-water interfacial tension of common surfactant A and JCN-001

Experimental results: The oil-water interface activity of surfactants has a great influence on the wettability and oil-washing effect of formation rocks changed by foaming agents.

The lower the oil/water interfacial tension of surfactants is, the better the oil/water interfacial activity of surfactants is. However, too low oil/water interfacial tension will also increase the difficulty of oil/water separation of surface produced crude oil. If other technologies are adopted to achieve oil/water separation, it will directly lead to the increase of economic cost in later stage.

At present, when the oil/water interfacial tension is in the range of 5×10-2~1×10-3 mN/m, the foaming agent not only has good oil/water interfacial activity, but also can guarantee the oil/water separation easily and reduce the production cost.

According to the oil-water interfacial tension test diagram, it can be clearly analyzed that compared with ordinary alkyl benzenesulfonic surfactant, the self-made nano oil displacement agent in this paper can achieve lower interfacial tension, and can also play a role in enhancing oil recovery under high temperature conditions.

2.4 Static adsorption experiment

In the process of oil displacement, the loss of surfactants due to sandstone or rock adsorption is very important, and the large amount of surfactant loss is one of the more difficult problems to solve [11], because it will directly affect the efficiency and cost of oil displacement Cause damage for detention surfactants in the formation of the main reasons are as follows [12]: first, when the surfactant into the formation, surface active agent and formation rock will occur, the solid-liquid interface adsorption phase behavior of this kind of undesirable makes surfactants was stagnant oil phase in the formation trap, [13] thus the surfactant adsorption phenomenon happened Second, the solubility of surfactants in the reservoir salinity water environment is poor, not fully dissolved can be deposited in the reservoir and lose the original effect of surfactants [14] .Therefore, the static adsorption loss experiment of surfactants and the adsorption loss experiment of surfactants in the process of dynamic oil displacement are important reference indexes. Through the comparative analysis of the static and dynamic adsorption loss experiment results, the influencing factors of the adsorption loss of surfactants in the process of oil displacement are studied [15].

Experimental steps: 300mL temperature resistant nano surfactant solution of 0.1%, 0.2%, 0.3%, 0.4% were prepared respectively, and the following experimental process was carried out:

(1) 300mL temperature resistant nano surfactant JCN-001 solution was taken, weighed 30g (80-120 mesh) oil sands were put into a 200mL triangular flask;

(2) Add 100g of temperature-resistant nano-type surfactant JCN-001 to the triangle flask sealed with plug and tape, put it into the high-temperature and high-pressure reactor, evenly shake it for 72h under 110, then remove it, centrifuge it at 4000r/min for 20min, take it out, the upper clarified liquid;

(3) The absorbance of the liquid after centrifugation was measured by ultraviolet spectrophotometer, and the concentration was obtained by using the standard curve formula. The concentration was denoted as one. The concentration after the first adsorption, and calculate the first adsorption amount according to the formula;

(4) Repeat the above experimental steps to calculate the adsorption capacity for the second and third time.

The static adsorption capacity is calculated as follows [16]:

$$A_i = [(\rho_0 - \rho_i)V]/m$$

$$A_n = \sum_{i=1}^{n} A_i$$

The experimental results: According to the shown in table 1, as the heat resistance nano surfactant concentration increasing, the single adsorption quantity and total adsorption capacity increased The highest adsorption quantity for the first time, the second adsorption capacity is low, basic unchanged for the third time the adsorption quantity By static adsorption experiment of rocks, the heat resistance of nano type surfactants in use process should choose low concentration.

Table 1. Static adsorption capacity at different concentrations

Original concentration (mg·L-1)	First adsorption (mg·L-1)	Secondary adsorption (mg·L-1)	Third adsorption (mg·L-1)	Cumulative adsorption capacity (mg·L-1)
1000	976.0056	982.0045	996.687	0.284562
2000	1965.6325	1982.5612	1996.9458	0.645214
3000	2946.6564	2941.6457	2986.9841	0.828612
4000	3960.1254	3962.1126	3982.2456	0.860576

3. Conclusion

A temperature-resistant nano-foam system was developed in the laboratory. By testing its particle size distribution, the experimental results can determine the average particle size range of the system is 34.29nm and the oil-water interfacial tension is measured at 110. The experimental results show that the nano-system can reach 10-4nm /m at high temperature, and the higher the temperature, the more significant the effect The static adsorption test shows that the temperature resistant nano surfactant JCN-001 has excellent adsorption resistance, and the optimal concentration is 0.2%.

References

1. He L, Luo J, Ding B, et al. Preparation and Properties of Nano Oil Displacement Agent for Low/Ultra-low Permeability Reservoir [J]. Oilfield Chemistry, 2018, 35(1): 81-84 and 90.
2. Lei Q, Luo J, Peng B, et al. Mechanism of expanding swept volume by nano-sized oil-displacement agent [J]. Petroleum Exploration and Development, 2019, 46(5):991-997.
3. Cheng Y, Zhao M, Zheng C, et al. Water-dispersible Reactive Nanosilica and Poly (2-acrylamido-2-methyl-1-propanesulfonic Acid Sodium) Nanoybrid as Potential Oil Displacement Agent for Enhanced Oil Recovery [J]. Energy & Fuels, 2017, 31(6):6345-6351.
4. Feng Q, Qu C, Zhang W, et al. Preparation and Performance Evaluation of Nano-Microsphere Oil Displacement Agent Suitable to Offshore Heavy Oil Field [J]. Journal of Liaoning Shihua University, 2019.
5. Zhang J H, Wang Y N, Wang X Y, et al. The performance evaluation of nano-micron microsphere for profile control and displacement agent in low permeability reservoir [J]. Iop Conference, 2016, 40:012020.
6. Harnoy G N. Enhanced oil recovery techniques using liposomes [J]. 2010.
7. Hendraningrat L, Torster O. Metal oxide-based nanoparticles: revealing their potential to enhance oil recovery in different wettability systems [J]. Applied Nanoscience, 2015, 5(2): 181-199.
8. Liu Q C, Liu Y J. Study on the Mechanism of Enhancing Oil Recovery by Molecular Film Displacement[C]// Advanced Materials Research. Trans Tech Publications, 2011:2135-2141.

9. MD Bhavsar, Amiji M M. Polymeric nano- and microparticle technologies for oral gene delivery. [J]. Expert Opinion on Drug Delivery, 2007, 4(3):197-213.
10. Sun Q, Li Z, Li S, et al. Experimental study on interface properties and oil displacement efficiency of foams stabilized by SiO2 nanoparticles [J]. Journal of China University of Petroleum (Edition of Natural ence), 2016.
11. Cheng Y, Jing D U, Luo W, et al. Synthesis and properties of oil displacement agent nanosilica grafted poly-acrylmide/ 2-acrylamido-2-methyl-1-propanesulfonic acid sodium [J]. Chemical Research, 2017.
12. Sun Z G, Zhang J, Xia J H, et al. Development of two novel composite oil displacement agents based on petroleum sulfonate [J]. Journal of China University of Petroleum (Edition of Natural Science), 2007.
13. Li Q, Wei B, Lu L, et al. Investigation of physical properties and displacement mechanisms of surface-grafted nano-cellulose fluids for enhanced oil recovery [J]. Fuel, 2017, 207(nov.1): 352-364.
14. Jie H, Tang D, Zhang J. Research of the compatibility and oil displacement result of molecular deposition membrane agent and polymer [J]. Petroleum Geology and Recovery Efficiency, 2009.
15. Zhang L, Jing C, Khan N, et al. Efficient Preparation of Nano-Starch Particles and Its Mechanism of Enhanced Oil Recovery in Low-PermeabilityOil Reservoirs [J]. SPE Journal, 2020:1-14.
16. Zhang Z L, Wang C J . Research progress on new oil-displacing agent in extra-low-permeability reservoir in Yanchang oilfield [J]. Applied Chemical Industry, 2018.