CHEMICAL ENGINEERING TRANSACTIONS
VOL. 62, 2017
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Fei Song, Haibo Wang, Fang He

ISBN 978-88-95608- 60-0; **ISSN** 2283-9216
DOI: 10.3303/CET1762035

Research on the Sewage Desalting Treatment and Anti-Scaling Technology for High Salt Oil Field

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In order to carry out the research on sewage desalting treatment and anti-scaling technology of high salt oil field, a high cost-effective scale inhibitor capable of maintaining higher scale-inhibiting efficiency under high temperature is preferably selected to effectively control scale formation in sewage equipment of high salt oil field with the mechanical compression evaporation and desalination process. Commercially available scale inhibitor on the market is screened to evaluate its performance by using the static anti-scaling method of national standard, thus select the cost-effective scale inhibitor. Meanwhile, the influence of heating temperature, heating time and the dosage of scale inhibitor on the effect of selected scale inhibitor is studied by changing the heating temperature, heating time and dosage of scale inhibitor and other conditions to determine the best application condition and parameter of scale inhibitor. Through the research on screening of six commonly used scale inhibitors, it is found that the scale inhibitor SQ-1211 is obviously of better effect under high temperature.

1. Introduction

Water scaling for oilfield is widespread in the production and development process of oilfield. During this process, the scale-forming ions in the formation water precipitate out gradually with the changes of external conditions such as temperature and atmospheric pressure, and become more and more serious as the development progresses (Chen et al., 2016). The treatment of high-salt wastewater has always been a problem (Wang et al., 2013). Treatment of high-salt oily wastewater with multi-effect evaporation by enterprises will make the actual temperature of wastewater up to 100°C. Due to less volume and high hardness of salt water, there is a strong trend of scale formation under high temperature (Hamill et al., 2017). At present, the research on scale inhibition technology is usually carried out under the condition of 60°C, and there are few studies on the scale inhibition effect of high-salt wastewater under the condition of high temperature. In this paper, the reaction temperature of 70°C, 80°C, 90°C and 100°C is selected to study the scale inhibition technology of high-salt wastewater under high temperature, which has strong practical significance (Pool, 2014).

2. Research on screening of six kinds of scale inhibitors

The reaction time is set as 24 hours, while the temperature of the control solution is 80°C, and the dosage of scale inhibitor is selected as 10, 20, 30, 40 and 50 mg/L, so as to study the rule of change on the scale inhibition rate of six scale inhibitors with the dosage. The experimental results are shown in Figure 1.
It can be seen from Figure 1 that for different scale inhibitors, the rule of change on scale inhibition effect with the dosage is different. When the dosage was 10mg/L, the scale Inhibitor 1 had a high inhibition rate of 91%. When the dosage was increased to 20mg/L, the scale inhibition rate plunged to 57% and then increased with the dosage. The scale inhibition rate of scale inhibitor 1 slightly increased and then gradually decreased, and finally stabilized. When the dosage increased from 10mg/L to 50mg/L, the scale inhibition rate of scale inhibitor 2 and 3 showed the trend of first increasing and then decreasing and finally stabilizing. The scale inhibition rate of scale inhibitor 4, 5 and 6 decreased with increase of dosage, and finally stabilized. The rule of

Please cite this article as: Gaoshen Su, Huan Yang, Yue Luo, 2017, Research on the sewage desalting treatment and anti-scaling technology for high salt oil field, Chemical Engineering Transactions, 62, 205-210 DOI:10.3303/CET1762035

change on scale inhibition effect with dosage on the one hand depends on the nature of scale inhibitor, on the other hand depends on the scale scaling trend of water sample.

It can be seen from the screening test result of the scale inhibitor in Figure 1 that among the selected six scale inhibitors, the scale inhibition effect of SQ-1211 is obviously different from that of the other five scale inhibitors. The scale inhibitor 1 is of the best effect when the dosage is only 10mg/L and the scale inhibition rate is up to 91%. It is a kind of scale and corrosion inhibitor with low dosage and high efficiency suitable for the water sample in this experiment.

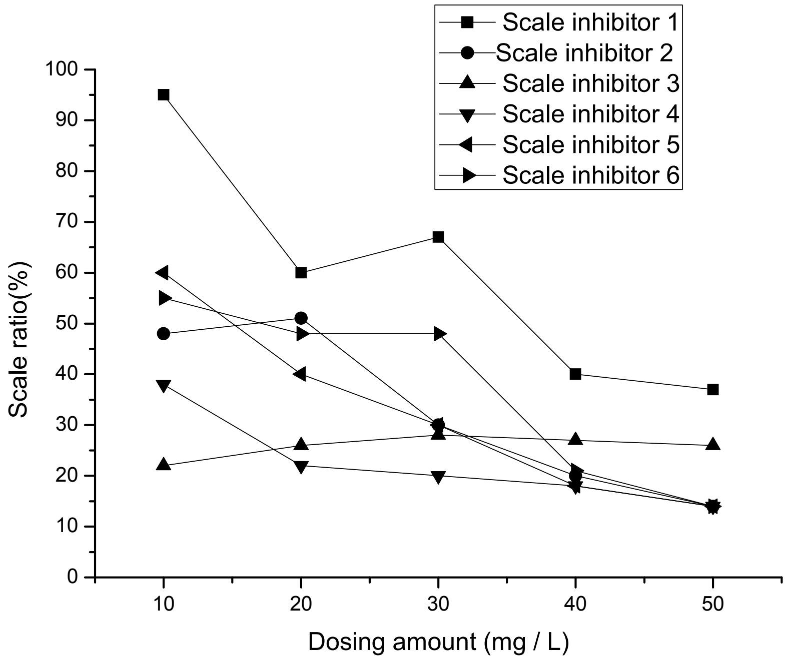

Figure 1: Effect of dosage on scale inhibition (solution temperature: 80℃, time: 24 hours)

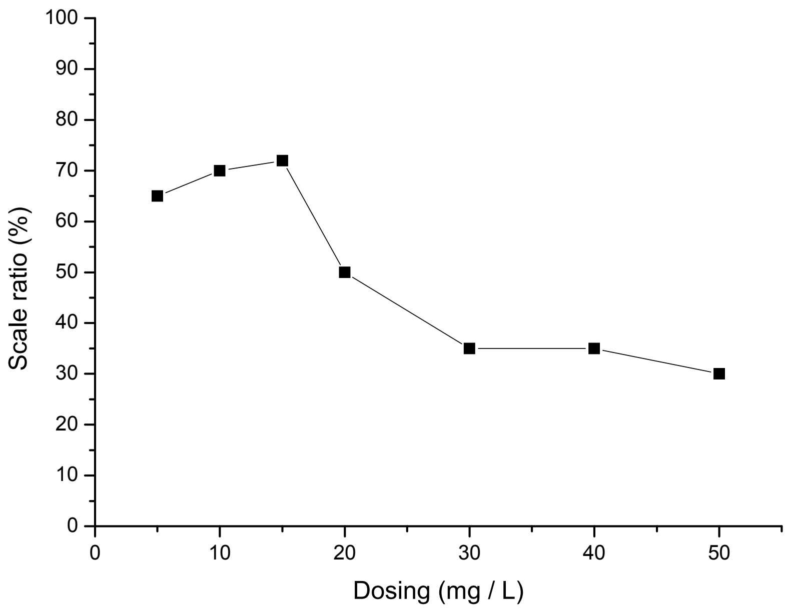

Figure 2: Scale inhibitor SQ-1211 scale inhibitor with the dosage of the change in the law (solution temperature: 100℃, time 24 hours)

3. Scale inhibitor SQ-1211

3.1 Dosage optimization experiment of scale inhibitor SQ-1211

Through the above experiment, it is found that scale inhibitor 1 has the best scale inhibition effect on the water sample (Yu et al., 2015). In order to further clarify the rule of change on scale inhibition performance of scale inhibitor SQ-1211 with the dosage and determine its best dosage, the dosage of scale inhibitor SQ-1211 is refined in the experiment (Hato et al., 2017), and the dosage gradient is selected as 0, 5, 10, 15, 20, 30, 40 and 50 mg to conduct the experiment of scale inhibition. The experimental results are shown in Figure 2.
The results show that the scale inhibition rate of scale inhibitor SQ-1211 shows a trend of first increase and then decrease with the increase of dosage. When the dosage was 10 mg/L, the scale inhibition rate reached 69%. When the dosage continued to increase to 15 mg/L, the scale inhibition rate only increased by 1%. It can be seen that under the conditions of temperature of 100°C, the reaction time of 24 hours and the dosage of 10mg/L, the scale inhibitor 1 almost reaches the maximum effect, and its scale inhibition effect is not obvious increased on continuing to lift away from the dosage (Yang and Yu, 2017). The scale inhibition effect decreases when the dosage is too large (Funnell et al., 2017). This is consistent with the experimental results at a temperature of 80°C.
Based on the above experimental results, it can be concluded that the optimal dosage of SQ-1211 is 10 mg/L when the reaction time is 24 hours and the solution temperature is less than 100°C, and the scale inhibition rate is not less than 69% (Baggen et al., 2017).

3.2 Influence of scale inhibitor dosage and reaction temperature on the scale inhibition effect

Static scale inhibition method is used to heat the test and blank water sample in a water bath at constant temperature for 10 hours. The dosage of scale inhibition is selected as 7, 9, 11, 14, 15 mg/L and the heating humidity is set as 70, 80, 90 and 100□ respectively to conduct experiment. The experimental results are shown in Figure 3.

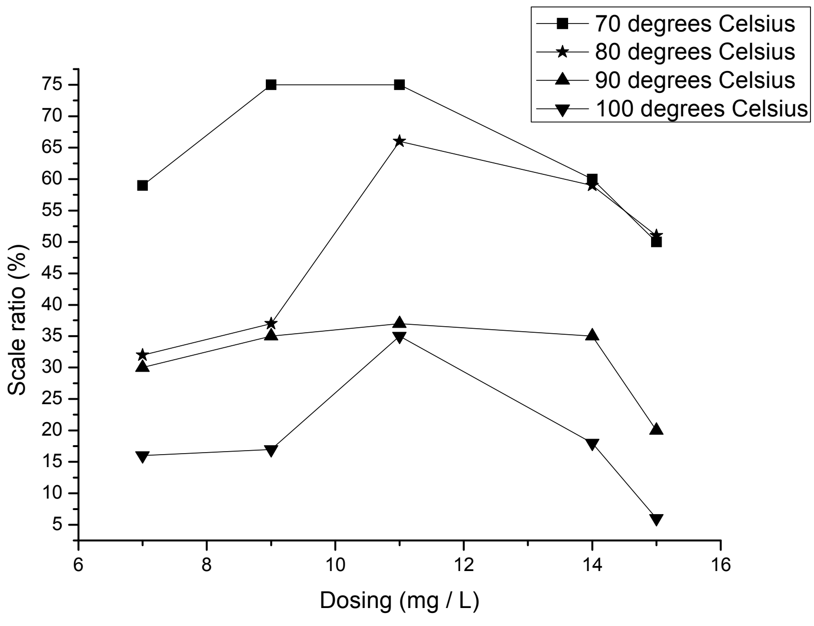

Figure 3: Effect of scale inhibitor dosage and reaction temperature on scale inhibition

It can be seen from Figure 3 that with the increase of scale inhibitor dosage, the scale inhibition rate first increases and then decreases (Lumbreras et al., 2017). At different reaction humidity, the scale inhibitor obtains the best scale inhibition effect when the dosage is 11 mg/L. In solution, the functional groups in the scale inhibitor molecules adsorb to the crystal surface of calcium carbonate under the action of electrostatic force, occupying the active growth point on the surface of the crystal of calcium carbonate, causing the lattice distortion of crystal of calcium carbonate, thus preventing crystal growth (Fernández-Ruiz et al., 2017). On the other hand, since the scale inhibitor molecules adsorbed on the surface of the crystal and dissociated in the solution carry the same charge, the crystals disperse each other according to the principle of same-sex repulsion so as to achieve the scale-inhibiting effect (Xiao et al., 2017). When the dosage of scale inhibitor exceeds the optimal dosage, the balance of the reaction is destroyed according to the threshold effect. Therefore, when the dosage exceeds 11 mg/L, scale inhibition effect will decline (Sasatani et al., 2017).

3.3 Influence of heating time on the concentration of calcium ion in test solution

The static scale inhibitor method is used to select the best scale inhibitor dosage of 11 mg/L; the temperature of water bath is controlled at 80°C; the heating time is selected as 6, 10, 14, 18 and 22 hours, so as to study the influence of heating time on the concentration of calcium ion in the test water sample. The initial calcium concentration is 1650 mg/L. The experimental results are shown in Figure 4.

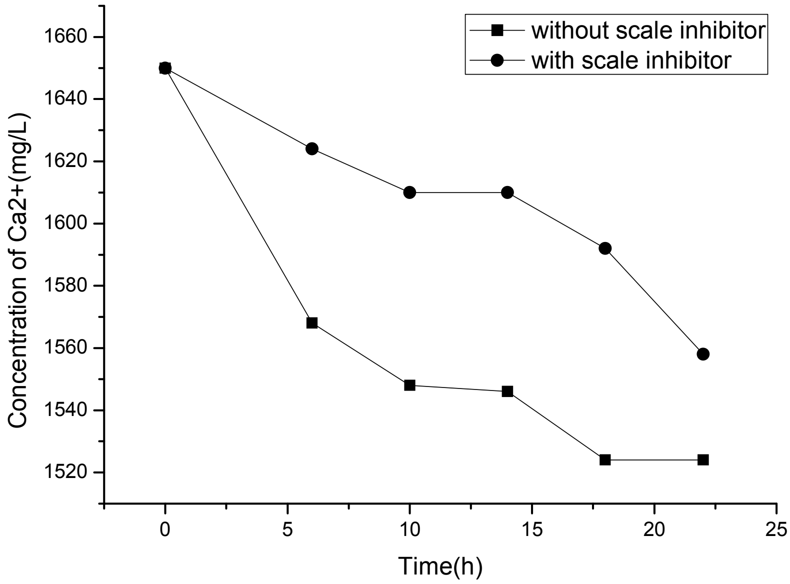

Figure 4: Effect of heating time on calcium ion concentration in solution (reaction temperature: 80 degrees Celsius)

It can be seen from Figure 4 that the calcium concentration in both blank and experimental solution decreases as the heating time increases (Wu et al., 2015). Compared with the experimental solution adding scale inhibitor, the concentration of calcium ion in the blank solution decreases more rapidly with the increase of heating time (Shahzad et al., 2017). Therefore, after the scale inhibitor is added, the trend of scaling can be significantly inhibited in solution. In the five hours prior to the experiment, the calcium concentration in the blank solution drops from 1640mg/L to 1568mg/L, while the calcium concentration in the solution with the addition of scale inhibitor drops to only 1622 mg/L. As the heating time increases, it can be seen from the figure that the scale inhibitor has a significant mitigation effect on the deposition of calcium ions. On the one hand, it is because the scale and corrosion inhibitor SQ-1211 can integrate the calcium ions in the solution to prevent its reaction with ammonia carbonate; on the other hand, the scale inhibitor molecules occupy the activity growth point of fouling crystal surface, so that the spray change of the lattice occurs, resulting in that the formed calcium carbonate precipitation is not easy to attach to the pipe surface and easy to wash away with the water. However, after 18 hours, the calcium ion concentration in the solution with the scale inhibitor starts to decline significantly, possibly because the stability of the scale inhibitor molecules decreases after heating at high temperature for a long time. Meanwhile, the calcium ion concentration in the blank solution tends to be stable with the complete precipitation of carbonate.

3.4 Influence of pH value on scale inhibition effect

The static scale inhibition method is used to select the best inhibitor dosage of 11 mg/L; the temperature of the water bath is controlled at 80°C and the heating time is set as 10 hours to study the influence of pH on scale inhibition effect. The influence of pH on scale inhibition effect is shown in Figure 5.

As shown in Figure 5, as the pH increases, the scale inhibition rate also shows a tendency to first increase and then decrease. At pH=8, the scale inhibition rate can reach 90.7%. Under acidic conditions, the scale inhibition effect is lower than that in alkaline environment, probably because the scale inhibitor is more stable under alkaline conditions. In addition, scale-forming ions in the blank solution are more likely to precipitate under alkaline conditions due to the chemical equilibrium. This also explains that although the concentration of calcium ions does not change significantly with the increase of pH in the solution to which the scale inhibitor is added, the scale inhibition at pH 6-7 is significantly lower than that at pH 8-10. As the pH increases, the OH- concentration in the solution increases, resulting in a shift of the reaction equilibrium between OH- and HCO3- to the right side, thus causing a reduction of HCO3- and an increase of CO32-. Therefore, in the range of pH 8-10, with the increase of pH, precipitation of calcium carbonate is more likely to occur in aqueous solution, and the scale inhibition effect is reduced. The scale inhibition rate at pH 8-10 gradually decreases.

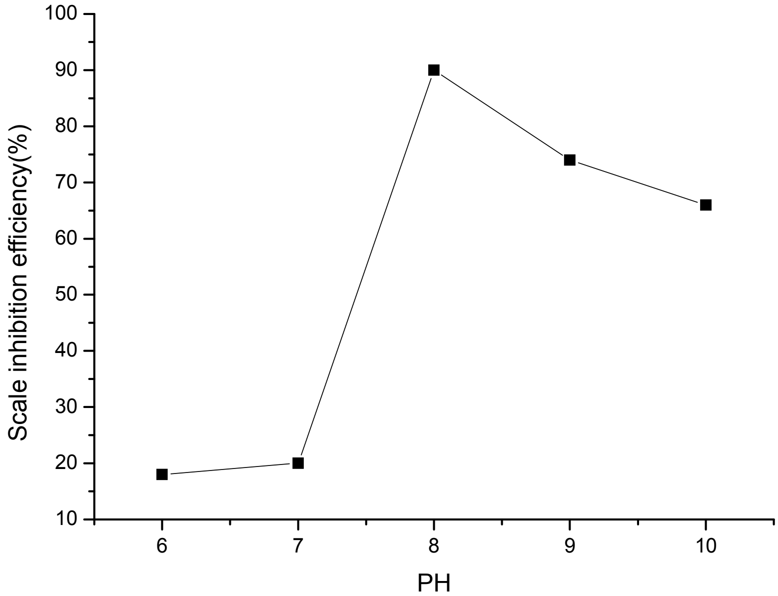

Figure 5: Effect of PH on scale inhibition (reaction temperature: 80℃, heating time: 10 hours)

3.5 Onsite effect experiment of scale and corrosion inhibitor SQ- 1211

In order to confirm the onsite scale inhibition effect of scale inhibitor, the scale and corrosion inhibitor SQ-1211 is put into field test. As the ion concentration analyzed by ion chromatography is low, the titration detection of Ca2+, Mg2+ is conducted in the commissioned technical test. The data is shown in Figure 6:

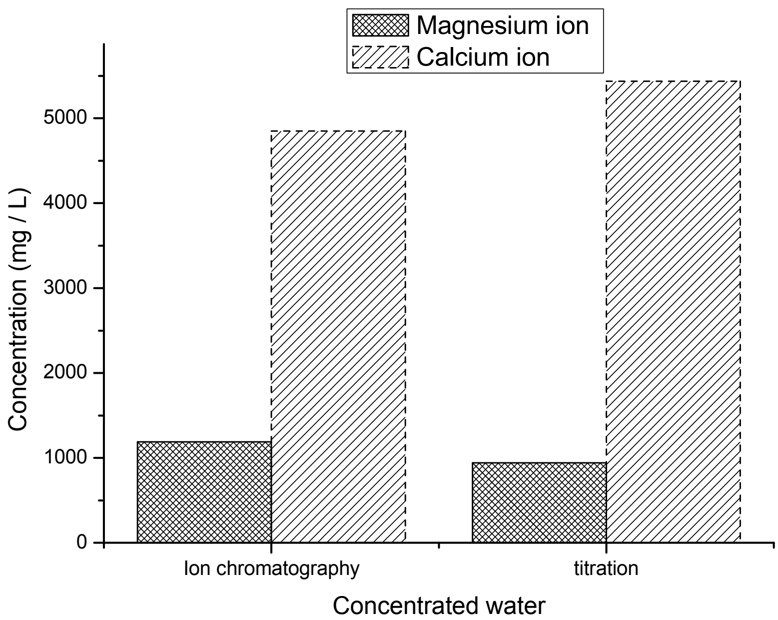

Figure 6: Ion chromatography and titration method measured concentrated calcium and magnesium ion concentration

4. Conclusion

Scale and corrosion inhibitor SQ-1211 has obvious scale inhibition effect on simulation of oily wastewater in Xinjiang Oilfield at high temperature. The dosage of scale inhibitor, reaction temperature, reaction time and pH of the solution all affect the scale inhibition effect. When the calcium ion concentration is 1600 mg/L, the optimal dosage of scale and corrosion inhibitor SQ - 1211 is 11 mg/L; when the reaction temperature rises from 70 to 100 ^{o}C, the scale inhibition effect of scale inhibitor decreases as the temperature increases. The optimal scale inhibition rate can reach 75.1% at 70^{o}C, while the best scale inhibition rate at 100^{o}C is only about 40%. Scale and corrosion inhibitor SQ - 1211 can delay the deposition of calcium ions in the simulated oily wastewater, thereby inhibiting the formation of scale ions. In the range of pH 6-8, scale inhibition rate increases with the increase of pH, while in the range of pH 8-10, the scale inhibition rate decreases with the increase of pH, and scale and corrosion inhibitor SQ - 1211 has the best scale inhibition effect at pH=8. When the reaction temperature is 80°C, the best scale inhibition rate can reach 90.7%.

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