

The Evaluation of Inhibitor for Water Injection Pipeline of one Oilfield

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Abstract: To solve the serious corrosion of oilfield injection pipeline in recent years, the sample of injection water and corrosion products were taken from injection station of one oilfield, according to the analysis of corrosion products by The X-ray diffraction and The X-ray spectrometer, the main reasons of corrosion are carbonate ions (or carbon dioxide gas) and the outcome of combined action of salts. So two kinds of imidazoline corrosion inhibitors were developed. Then the components of injection water were analysed, the efficiency of inhibitor and corrosion mechanism of the two kind of corrosion inhibitors were evaluated by weight loss method and electrochemical method, the experimental results show that two kinds of corrosion inhibitors have better effect on the water injection system corrosion, The corrosion effect is better when two kinds of inhibitors LED and ODD by 1:3 proportion distribution compound.

1. Introduction

Oilfields often use treated oilfield produced water for reinjection to improve oil recovery. The treated oilfield produced water has the characteristics of high salinity and alkalescence. In recent years, investigations have found that corrosion and perforation of oilfield water injection pipelines are very common [1]. Therefore, corrosion and corrosion prevention of oilfield water injection pipelines have been paid more and more attention. At present, injecting preservative is still an effective method to control corrosion of oil field water injection pipelines [2]. In this paper, through the analysis of the water injection quality and corrosion products of a water injection station, two kinds of imidazoline corrosion inhibitors with doped quaternary ammonium salt group and ethoxy group were developed for their corrosion characteristics, which were evaluated by weight loss method and electrochemical method. The corrosion inhibition effect and the optimum dosage of the corrosion inhibitor were studied, and the two corrosion inhibitors were compounded experimentally, which provided an effective antiseptic method for the oilfield water injection system.

2. Water Quality Analysis and Corrosion Product Analysis

2.1 Experimental medium

The experimental medium is sampled at a standard sampling point on the spot of a water injection station and tested for ion concentration. See Table 1 for various ion contents. The experimental medium is configured with deionized water according to various ion concentrations in the laboratory.

Table 1 The ion content of injected water quality

| Ion | Water content(mg/L) | Ion | Water content(mg/L) | Ion | Water content(mg/L) |
|---------------------------------|---------------------|-------------------------------|---------------------|----------------|---------------------|
| K ⁺ ,Na ⁺ | 400.7 | Cl ⁻ | 833.1 | Sr | 3.91 |
| Ca ²⁺ | 172.3 | SO ₄ ²⁻ | 283.4 | Ba | 0.11 |
| Mg ²⁺ | 144.6 | HCO ₃ ⁻ | 537.0 | PH value | 7.85 |
| NH ₄ ⁺ | 5.01 | CO ₃ ²⁻ | 0.0 | Total salinity | 2376.10 |

2.2 Sample preparation

The test piece required for this experiment is made of water injection pipeline steel, the material

is No. 20 pipeline steel, and its chemical composition is shown in Table 2.

Table 2 Chemical composition of No. 20 pipeline steel(%)

| Product name | Chemical composition (mass percent) | | | | | | | |
|--------------|-------------------------------------|----------------|-------------|----------------|-----------|-------------|--------------|-------------|
| | Carbon(c) | Manganese (Mn) | Silicon(Si) | Phosphorus (p) | Sulfur(s) | Nickel (Ni) | Chromium(Cr) | Copper (Cu) |
| No.20 steel | 0.20 | 0.45 | 0.18 | 0.03 | 0.025 | 0.20 | 0.20 | 0.23 |

The self-made corrosion test piece was tested. The size of the test piece for observation of corrosion morphology was 25×10×2(mm) and the size of the test piece for electrochemical measurement was 10×10×2(mm×mm×mm). The processed test piece is processed according to the experimental requirements. The sample is degreased and dusted with acetone using a clean tweezers. Then the sample is cleaned with absolute ethanol, and the sample is blown dry with a cold air blower. The sample was placed in a prepared dry dish for drying for experimental use [3].

2.3 Electrochemical measurement

The electrochemical experiment equipment adopts the American M2273 electrochemical test system, which is a 3-electrode system: The working electrode is No. 20 pipeline steel, the reference electrode is saturated calomel electrode, and the auxiliary electrode is platinum plate. The scanning speed of polarization curve of No. 20 pipeline steel is 0.5mV/s. The self-corrosive current density i_{corr} is compared by extrapolation method, and its variation law is observed. The AC impedance spectrum of 5 MHz to 100 khz is used to test the frequency, the sine wave amplitude of the excitation signal is 10mV, and Zsimpwin software is used to analyze the AC impedance spectrum.

3. Corrosion Product Analysis

On-site investigation and development found that the corrosion and scaling of water injection pipeline in this water injection station is serious. The scaling layer formed by the accumulation of long-term corrosion and scaling of water injection pipeline overlaps. When hot diesel oil is used to wash the pipeline, the scaling layer is decomposed into thin sheets, and the collected scaling samples are small scales of various thicknesses, as shown in Figure 1. The corrosion morphology of the corrosion product surface was observed by X-ray diffraction pattern, and the corrosion product was analyzed by KEVEX 8000 X- ray energy spectrometer. Quantitative analysis of corrosion products by EDS and qualitative analysis by X-ray diffraction are shown in Figure 2 and Figure 3. The results of EDS analysis of corrosion products by samples are shown in Table 3.



Fig.1. Typical corrosion products removed from diesel oil after hot washing

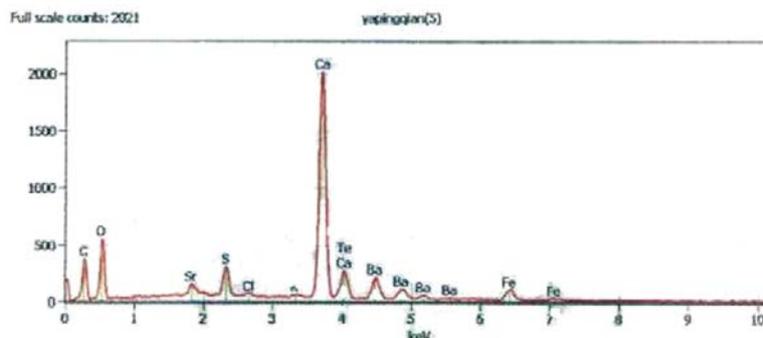


Fig.2. Energy spectrum of corrosion products of specimen

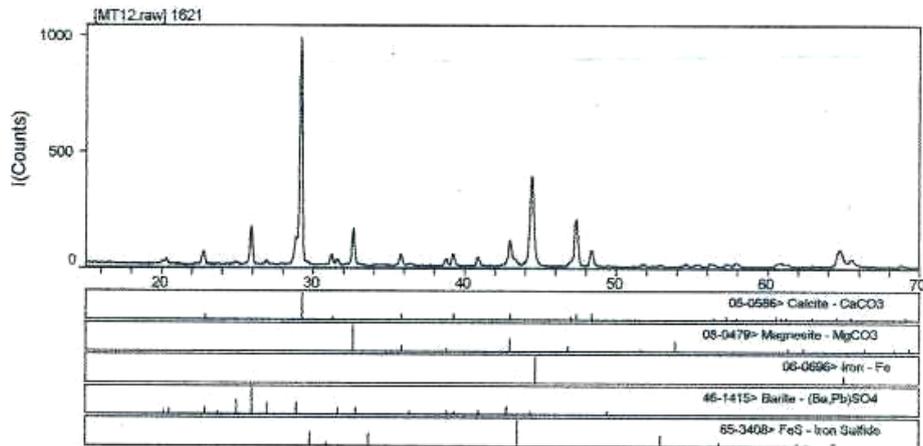


Fig.3. X-ray diffraction pattern of corrosion products of samples

The corrosion products of the samples were observed by scanning electron microscope, energy spectrum quantitative analysis and X-ray diffraction qualitative analysis. The results are as follows: The main components of the corrosion products are CaCO_3 and elemental Fe, and a small amount of BaSO_4 , FeS. The product is reddish brown, powdery and has poor adhesion. The main reason for corrosion is the combined action of carbonate ions (or carbon dioxide gas) and salts.

4. Corrosion Inhibitor Evaluation Experiment and Analysis of Experimental Results

According to the water quality characteristics of the water injection station and the analysis of corrosion products, two corrosion inhibitors LED and ODD suitable for the water quality characteristics of the water injection were developed. Both corrosion inhibitors are imidazoline corrosion inhibitors, which respectively introduce a doped quaternary ammonium salt group and an ethoxy group. The evaluation of corrosion inhibitors is mainly based on the petroleum industry evaluation standard SY/T 5273-2000 “Performance Evaluation Method for Corrosion Inhibitors for Oilfield Produced Water” [4].

4.1 Weight loss method for evaluating corrosion inhibitor

The experimental temperature of the corrosion inhibitor was evaluated by the weight loss method. The optimum water injection temperature was $60\text{ }^\circ\text{C}$, the experimental period was 96 hours, and the corrosion inhibitor concentration was mass percentage. Based on the experimental results, the relationship between the corrosion inhibition efficiency and the concentration of the inhibitor is plotted, as shown in Fig. 4 and Fig. 5.

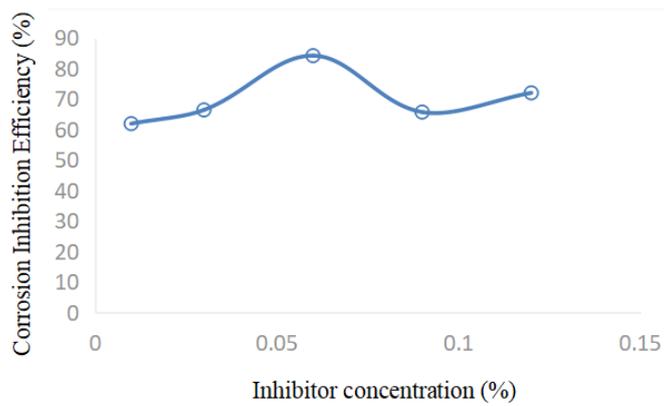


Fig.4. Relationship between inhibition efficiency and concentration of inhibitor ODD

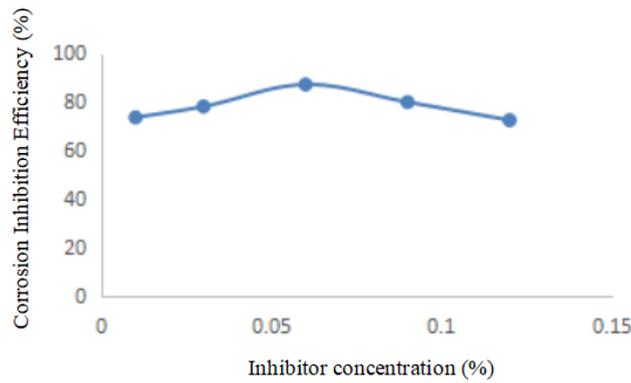


Fig.5. Correlation curve between corrosion inhibition efficiency and concentration of corrosion inhibitor LED

By comparing the experimental results of the above experiments, it is found that the optimal concentration of the two corrosion inhibitors is 0.06% at 60°C, and the inhibition efficiency of ODD and LED corrosion inhibitors at the optimal concentration is 84.2% and 87.0% respectively. Both of the two inhibitors have good corrosion inhibition effect on the water injection pipeline, and the corrosion inhibition efficiency of the inhibitor LED is higher under the same conditions.

4.2 Evaluation of corrosion inhibitors by electrochemical method

The experimental temperature was 60°C, The sample size is 10×10(mm×mm) with a mass of 800g g. The polarization curves of LED and ODD with different concentrations of corrosion inhibitor are shown in Figure 6 and Figure 7.

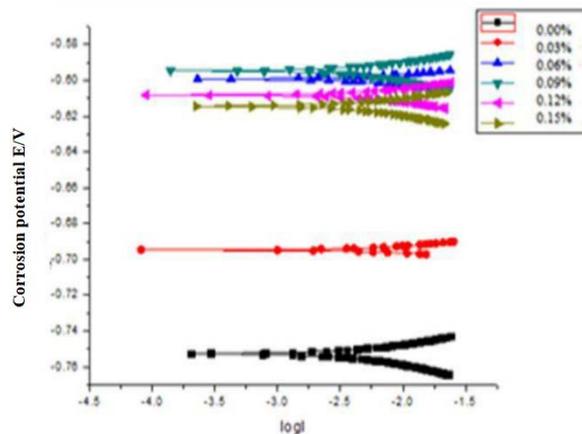


Fig.6. Combination chart of polarization curves of corrosion inhibitor LED at different concentrations

It can be seen from Fig. 6 that after the corrosion inhibitor LED is added to the simulated oilfield reinjection water quality experiment, as the corrosion inhibitor concentration increases, the self-corrosion potential of the system gradually moves to the positive direction, and the cathode and cathode corrosion current density gradually shifts to the left. The cathode and anode of the corrosion process are simultaneously inhibited and enhanced [5]. Compared with the blank group, the slope of the cathode curve increases first and then decreases. The increase of the slope indicates that the polarization resistance increases and the polarization current decreases correspondingly, and the cathode reaction is inhibited. The decrease in slope indicates that the polarization resistance decreases, the polarization current increases correspondingly, and the inhibition effect on the cathode reaction decreases. This is because the corrosion of metal is weakened by the adsorption of inhibitor molecules on the electrode surface or the formation of corrosion product film on the electrode surface in the initial stage. However, with the increase of potential, the corrosion inhibitor adsorbed on the electrode surface appears desorption phenomenon [6]. According to the

electrochemical parameters of the polarization curve measured, the corrosion potential increases first and then decreases, and the corrosion current decreases first and then increases. When the inhibitor concentration is 0.06%, the corrosion current is the smallest. Therefore, for this water quality, the optimal concentration of the inhibitor LED is 0.06%.

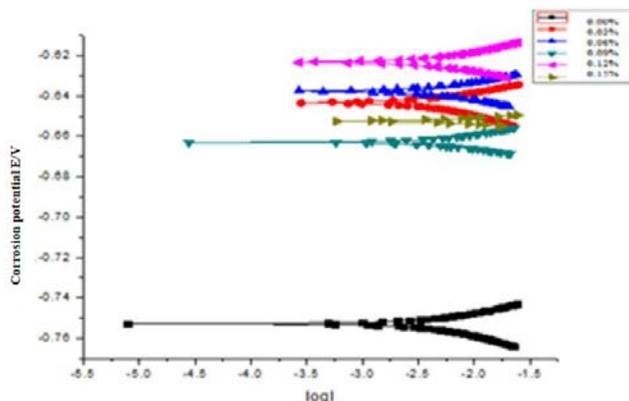


Fig.7. Combination chart of polarization curves for different concentrations of corrosion inhibitor ODD

It can be seen from Fig. 7 that in the simulated oilfield re-injection water quality experiment, as the corrosion inhibitor ODD concentration increases, the self-corrosion potential of the system gradually moves to the positive direction and the cathode-anode corrosion current density gradually shifts to the right, and the corrosion process is negative. The anode is simultaneously inhibited and continuously enhanced. Compared with the polarization curve without adding corrosion inhibitor, the corrosion potential of the cathode curve gradually moves forward, which shows that the polarization rate is higher, the film forming speed is faster, and the film has good protection [7]. From the electrochemical parameters of the measured polarization curve, it can be seen that the corrosion potential increases first and then decreases, and the corrosion current decreases first and then increases. When the concentration of corrosion inhibitor is near 0.06%, the variation of corrosion current is very small, which indicates that the corrosion inhibitor has a protective effect on the electrode surface when the concentration is near 0.06%, so the inhibition effect is the best when the concentration of ODD is near 0.06%. The experimental results are consistent with the experimental results of the weight loss method.

4.3 Two corrosion inhibitor compounding experiments

The corrosion inhibition effect and electrochemical impedance spectroscopy of the corrosion inhibitor LED and ODD in the volume ratio of 1:1; 1:3 and 3:1 were measured by weight loss method and electrochemical experiment to verify the corrosion inhibition effect after compounding. The experimental results obtained by weightlessness method are shown in Table 3, and the electrochemical impedance spectra obtained by mixing in different proportions are shown in Figure 8.

Table 3 Corrosion inhibition efficiency when corrosion inhibitor LED and ODD are moderated at different ratios

| Mixing ratio | LED:ODD=1:1 | LED:ODD=1:3 | LED:ODD=3:1 |
|------------------------------------|-------------|-------------|-------------|
| Corrosion inhibition efficiency(%) | 88.7 | 92.3 | 86.1 |

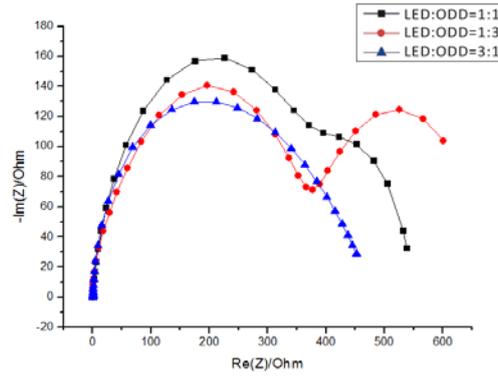


Fig.8. LED: NyOquist combination map after ODD=1:1, 1:3, 3:1

The NyOquist diagram is fitted by ZSimpWin3.0 analysis software. The fitting circuit is shown in Figure 9, where R_s is solution resistance. C_d represents the electric double layer capacitance between the research electrode and the solution where dispersion effect occurs. R_p is polarization resistance; Q_1 and Q_2 are diffusion constant phase angle elements, R_{t1} and R_{t2} are charge transfer resistors.

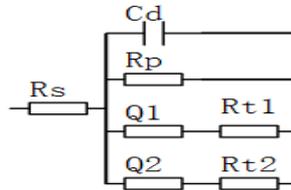


Fig.9. Equivalent circuit diagram of impedance spectrum fitting data under different ratios

It can be seen from the NyOquist diagram of the electrochemical impedance spectroscopy under different proportions. The impedance spectrum shows two capacitive reactance arcs, and the low-frequency capacitive anti-arc is more significant, which is related to the Faraday process of the electrode. High-frequency capacitive arc resistance, associated with the formation of corrosion-inhibiting films, typically surface dielectric films have a small time constant. The existence of corrosion inhibitors greatly increases the transmission resistance of corrosion reaction, and thus plays an inhibitory role, that is, the anodic dissolution process of metals is controlled by activation. The capacitance of the double layer on the surface of the electrode decreases significantly with the existence of corrosion inhibitor, which is due to the adsorption of film on the surface of the electrode, and the thicker the film, the smaller the interface capacitance. At LED:ODD =1:3, the charge transfer resistance R_{t2} is the largest, which reduces the corrosion current and weakens the corrosion reaction. This is due to the increase of time, the polarization resistance of the system obviously increases, while the differential capacitance of the system obviously decreases. This is because the surface film tends to be complete and the thickness of the film also increases with the increase of time [8]. In the corrosion solution of corrosion inhibitor LED: ODD=3:1, the electrochemical impedance spectrum shows a single time constant, that is, the single-capacity anti-arc feature, which is an adsorption-type corrosion inhibitor system, and the corrosion inhibitor does not participate in the electrode reaction. No intermediate product such as an adsorption complex is produced. Observing the image after corrosion with the naked eye, when the LED: ODD=3:1, the corrosion is more serious than the other two cases; when the LED: ODD=1:1 is mixed, the charge transfer resistance value is between the two. Therefore, when the two corrosion inhibitors are mixed at a ratio of 1:3, the corrosion inhibition effect is better.

5. Conclusion

Through the analysis of the corrosion products of the water injection station, the main reason for the corrosion of the water injection system of the water injection station is the interaction of

carbonate ions (or carbon dioxide gas) and salts. The two imidazoline Corrosion Inhibitors developed have good corrosion inhibition effect. Under the same conditions, corrosion inhibitor LED has better corrosion inhibition effect, and the optimal concentration of each corrosion inhibitor at the optimal water injection temperature of 60°C is determined to be 0.06%. The compound experiment shows that the corrosion inhibition effect is better when the two corrosion inhibitors are mixed at a ratio of 1:3.

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