

Analysis of Two Kinds of Chemical Reagents on Improvement of Local Soil Corrosion Environment

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Abstract. Soil environment is one of main influence factors for buried pipeline corrosion. In order to improve soil corrosion environment, some physical and chemical methods are available. The aim of this work is to evaluate validities of two kinds of chemical reagents for improving soil corrosion environment because of microbiological activity, which includes three corrosion inhibitors and three bactericides. Several groups of laboratory experiments on corrosion simulation are carried. Corrosion rate of steel test piece and sterilization rate of bactericides are calculated. Experimental results show that corrosion inhibitors and bactericides are effective to improve corrosive soil environment, which have different effects on corrosive soil. Optimal reagent and concentration in this work could be obtained. This research can provide effective anti-corrosion measure for buried pipeline.

Introduction

Corrosion is one of main factors for buried metal pipeline damage. And soil is main carrier which causes the metal pipe corroded complexly^[1, 2]. It has been well accepted that microbiological corrosion (MC) is one of the most damaging failure mode for buried pipeline in soils^[3]. In research soil, sulfate reducing bacteria (SRB) exists universally which induces metal pipe corroded. Soil environment becomes a focus of investigation. Now, many studies of soil characteristics and interaction with the metal surface have carried^[4-7], but studies on improving soil environment are few. So, aim at soil, chemical methods on improving local soil environment are investigated.

Corrosion inhibitors and bactericides are widely used in fluid medium within metal pipeline to solve inner corrosion of pipe^[8-11]. In order to prevent metal pipeline from external corrosion, cathodic protection and anti-corrosive coating materials are adopted in actual pipeline engineering. In this work, soil environment is taken as a focus to improve pipeline corrosion. Also, the idea for solving inner corrosion is applied on soil environment for solving external corrosion of buried metal pipeline. That is corrosion inhibitors and bactericides used in local corrosive soil. Three corrosion inhibitors and bactericides are selected in these experimental researches. Comparisons of these reagents on anti-corrosion are made, and optimal inhibitor and bactericide are obtained for this work.

Research Method

Corrosion inhibitors and bactericides are used widely in dealing with industry water which induces inner corrosion of metal pipe or equipment. Considered effects of these reagents, Sodium fluorosilicate (Na_2SiF_6), Sodium benzoate ($\text{C}_6\text{H}_5\text{CO}_2\text{Na}$), Sodium dodecyl sulfate ($\text{C}_{12}\text{H}_{25}\text{SO}_4\text{Na}$) were selected as corrosion inhibitors, Chlorine Dioxide (ClO_2), Sodium Hypochlorite (NaClO), Glutaric dialdehyde ($\text{C}_5\text{H}_8\text{O}_2$) were selected as bactericides. Soil solution specimens were made by spot soil of Daqing Oil field. Then 3 concentrations for corrosion inhibitors and bactericides were

designed. New and smooth test pieces of 20[#] steel shown as figure 1(a) were used to observe corrosive phenomenon in corrosion inhibitors experiments. Table 1, 2 shows basic experimental data of corrosion inhibitors and bactericides respectively.



Fig.1 Appearance of 20[#] Steel Piece during the Whole Experiment

Tab.1 Basic Data of Corrosion Inhibitor Experiment

Name of corrosion inhibitors	Concentration(mg/L)	No. of metal piece	Weight before corrosion(g)
Na ₂ SiF ₆	0	K①	18.8743
		K②	18.5721
		K③	18.3653
	100	F-1①	18.0327
		F-1②	18.4823
		F-1③	18.3728
	200	F-2①	18.6303
		F-2②	18.692
		F-2③	18.3335
	300	F-3①	18.534
		F-3②	18.8175
		F-3③	18.6092
C ₆ H ₅ CO ₂ Na	100	B-1①	18.6883
		B-1②	18.7411
		B-1③	19.0408
	200	B-2①	18.6627
		B-2②	18.351
		B-2③	18.433
	300	B-3①	20.6643
		B-3②	18.3579
		B-3③	20.6784
C ₁₂ H ₂₅ SO ₄ Na	100	S-1①	19.7539
		S-1②	18.3477
		S-1③	18.0558
	200	S-2①	18.4261
		S-2②	18.5996
		S-2③	18.5667
	300	S-3①	19.0641
		S-3②	18.9444
		S-3③	18.6907

Tab.2 Basic Data of Bactericides Experiment

Name of bactericides	Concentration of solution(mg/L)					
ClO ₂	5	10	20	30	40	50
NaClO	20	30	40	50	60	70
C ₅ H ₈ O ₂	2.5	5	10	15	20	-

Results and Discussions

Corrosion Inhibitors

When test period of corrosion inhibitors was over, test steel pieces corroded were dealt with. Representative of corroded appearance of test pieces was shown as figure 1(b), (c). Then corrosive

rate of different concentration of different corrosion inhibitors was calculated, and shown as table 3-5.

Tab.3 Experimental Results of Inhibition Efficiency under Different Concentration of Na_2SiF_6

Concentration of Na_2SiF_6 (mg/L)	Weight losing (g)	Average weight losing (g)	Corrosive rate (mm/a)	Inhibition efficiency (%)	Corrosion level
0	0.0503	0.0520	0.2814	—	Moderate corrosion
	0.0489				
	0.0567				
100	0.0460	0.0431	0.2332	17.1	Moderate corrosion
	0.0423				
	0.0409				
200	0.0496	0.0487	0.2635	6.4	Moderate corrosion
	0.0437				
	0.0527				
300	0.0428	0.0413	0.2238	20.5	Moderate corrosion
	0.0379				
	0.0433				

Tab.4 Experimental Results of Inhibition Efficiency under Different Concentration of $\text{C}_6\text{H}_5\text{CO}_2\text{Na}$

concentration of $\text{C}_6\text{H}_5\text{CO}_2\text{Na}$ (mg/L)	Weight losing (g)	Average weight losing (g)	Corrosive rate (mm/a)	inhibition efficiency (%)	Corrosion level
100	0.0166	0.0193	0.1043	62.9	Moderate corrosion
	0.0191				
	0.0221				
200	0.0168	0.0183	0.0993	64.7	Light corrosion
	0.0187				
	0.0195				
300	0.0126	0.0120	0.0648	77	Light corrosion
	0.0105				
	0.0128				

From figure 1(a), surface of new test piece is smooth. When these new pieces are immersed in soil solution with different corrosion inhibitor added in, also with different concentration, corrosion levels of these steel pieces were different. From figure 1(b), thin corrosive adhered to surface of steel piece, and corrosive pits are distributed irregularly which can be seen from figure 1(c). Furthermore, from table 3-5, inhibition efficiency of corrosion inhibitor will improve with the increasing of concentration except Na_2SiF_6 . When concentration of Na_2SiF_6 is 200mg/L, inhibition efficiency of it is the lowest. Inhibition efficiency of $\text{C}_6\text{H}_5\text{CO}_2\text{Na}$ is the best, especially the concentration of 300mg/L. So, $\text{C}_6\text{H}_5\text{CO}_2\text{Na}$ is the optimal selection of corrosion inhibitor in this research.

Tab.5 Experimental Results of Inhibition Efficiency under Different Concentration of $\text{C}_{12}\text{H}_{25}\text{SO}_4\text{Na}$

Concentration of SDS(mg/L)	Weight losing (g)	Average weight losing (g)	Corrosive rate (mm/a)	inhibition efficiency (%)	Corrosion level
100	0.0327	0.0338	0.1828	35	Moderate corrosion
	0.0332				
	0.0354				
200	0.0298	0.0315	0.1704	39	Moderate corrosion
	0.0299				
	0.0347				
300	0.0236	0.0220	0.1193	57.6	Moderate corrosion
	0.0193				
	0.0232				

Bactericides

In this research region, grassland, marsh and farmland are distributed. Content of microorganism in soil is very high. Sulfate reducing bacteria(SRB) is main corrosion factor for buried pipeline, so bactericides are used to improving local soil environment. Aiming at ClO_2 , NaClO and $\text{C}_5\text{H}_8\text{O}_2$, contrast tests are done. The results of sterilization rate are shown as table 6-8.

Tab.6 Sterilization Rate of ClO₂ (%)

Time(d)	Concentration of ClO ₂ (mg/L)					
	5	10	20	30	40	50
4	98.4	100	100	100	100	100
5	97.2	100	100	100	100	100
6	97.2	98.8	100	100	100	100
7	94	97.2	98.8	100	100	100
8	94	97.2	98.8	100	100	100
9	94	97.2	97.6	100	100	100
10	94	97.2	97.6	100	100	100
11	94	97.2	94	100	100	100
12	94	97.2	94	100	98.4	100
13	94	97.2	94	98.8	98.4	100
14	94	97.2	94	98.8	98.4	100

From table 6-8, the sterilization effect of three bactericides is, C₅H₈O > ClO₂ > NaClO. Table 9 shows that sterilization rate of C₅H₈O will increase with the increase of its concentration, and sterilization rate is almost 100% from concentration 2.5mg/L to 10mg/L. When the concentration of C₅H₈O keeps on increasing, sterilization rate arrives at the maximum. Table 7 shows that sterilization effect of NaClO is not obvious with the increase of its concentration, and sterilization rate is the highest at concentration 70mg/L which approaches the sterilization effect of concentration 60mg/L. When the concentration is lower than 30mg/L, the effect of sterilization is very bad. Table 6 shows that sterilization rate of ClO₂ is higher than 94%. When the concentration of ClO₂ is larger than 30mg/L, sterilization rate is nearly 100%.

Furthermore, during the experimental period, sterilization rate decreases with the increase of sterilization time, which is related with growth time of bacteria. Because experimental period include cultivating SRB and sterilization of bactericide, there is no SRB during initial stage and sterilization rate of bactericide is 100%. SRB will increase with the time longer, and sterilization effect of bactericide is visualized which is decreasing.

Finally, optimal concentration of these bactericide in this research are ClO₂ 30mg/L, NaClO 70mg/L, C₅H₈O 10mg/L, respectively.

Tab.7 Sterilization Rate of NaClO (%)

Time(d)	Concentration of NaClO (mg/L)					
	20	30	40	50	60	70
4	98.8	98.8	98.8	98.4	100	100
5	95.6	82	97.2	98.4	98.4	98.4
6	88	82	94.4	94.4	98.4	98.4
7	88	54	82	94.4	98.4	98.4
8	88	54	82	90	94.4	98.4
9	88	54	82	90	94.4	98.4
10	88	54	82	90	94.4	98.4
11	88	54	82	90	94.4	98.4
12	0	54	82	90	94.4	98.4
13	0	54	82	90	94.4	98.4
14	0	54	82	90	94.4	98.4

Tab.8 Sterilization Rate of C₅H₈O (%)

Time(d)	Concentration of C ₅ H ₈ O mg/L)				
	2.5	5	10	15	20
4	100	100	100	100	100
5	100	100	100	100	100
6	98.8	100	100	100	100
7	98.8	98.8	100	100	100
8	97.2	97.6	100	100	100
9	97.2	97.6	100	100	100
10	97.2	97.6	100	100	100
11	97.2	97.6	100	100	100
12	95.6	97.6	100	100	100
13	95.6	97.6	100	100	100
14	95.6	97.6	98.4	100	100

Summary

In order to improve local soil environment surrounding buried pipeline, the effects of corrosion inhibitors and bactericides are investigated by laboratory tests. Some conclusions are obtained.

- (1) Corrosion inhibitor and bactericide with proper concentration can be used in corrosion soil to improve soil environment and prevent buried pipeline corroded.
- (2) Corrosion levels of steel pieces were different with different corrosion inhibitor. Also, inhibition efficiency of corrosion inhibitor will improve with the increasing of concentration except Na_2SiF_6 .
- (3) $\text{C}_6\text{H}_5\text{CO}_2\text{Na}$ with the concentration of 300mg/L is the optimal selection of corrosion inhibitor in this research.
- (4) The order of sterilization effect of three bactericides is, $\text{C}_5\text{H}_8\text{O} > \text{ClO}_2 > \text{NaClO}$. And optimal concentration of these bactericide in this research are ClO_2 30mg/L, NaClO 70mg/L, $\text{C}_5\text{H}_8\text{O}$ 10mg/L, respectively.

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