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The New-generation of Green Surfactant (Alkylpolyglucoside) as an Inhibitor to the Corrosion of 907 Steel in Seawater

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Abstract: Weight-loss trials and potentiodynamic polarization curves have been used to study the inhibitive properties of alkylpolyglucoside (APG) towards the 907 steel in seawater. The inhibition was different, if the length of alkyl chain APG was different. As the result, calcium gluconate, zinc sulfate and APG can protect 907 steel from being corrupted in static seawater. The compound corrosion inhibitor was found to control both the anodic process and the cathodic process.

Keywords: Alkylpolyglucoside(APG), 907 steel, inhibitor, seawater.

Nowadays corrosion inhibitor is one of the most efficient way than all other methods against corrosion. And the most widely used corrosion inhibitors are for oil and gas deposit and refinery, mechanicals, chemical engineering, energy sources and so on[1]. But only few reports about corrosion inhibitors for steel in seawater have been found.

APG can be biodegradable in one hundred percent, so it is called green product[2]. It is used widely, but no report about APG used to protect carbon steel in seawater has been found. This paper is concerning the study on the inhibition of APG towards the 907 carbon steel in static seawater. This action was validated by weight-loss trials and potential polarization curves.

Experimental

The experimental sample was 907 carbon steel. The tested electrode's dimension was 1.10 cm×0.90 cm×0.50 cm. Only one surface was exposed, the other five surfaces were all sealed with resin. The sample dimension for weight-loss experiment was 4.00 cm×1.90 cm×0.70 cm and there was a small hole (Φ= 0.30 cm) for be hanging.

All experiments were conducted in quiescent, natural seawater at room temperature. Before experiment, the 907 carbon steel electrodes were treated with 320＃,500#,1000# abrasive paper and 4# metallographic abrasive paper gradually, then washed with distilled water and acetone. IM6e electrochemistry workstation (ZAHNER eletrik, The third technology item of Department of Education of Shandong province（J02C52）made in Germany) was used for electrochemistry experiment. Classic three-electrode device was adopted in the experiments (R: SCE; A: Pt; W: 907 carbon steel). In weight-loss trials,

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the carbon steel was completely immersed in seawater for 7d.

Results and Discussion

The inhibitory property of single APG component

The effect of adding surfactants with different types of hydrophilic groups was studied in order to improve their performance as a corrosion inhibition for steel in seawater[3,4]. The potentiodynamic polarization curves for carbon steel in each solution of APG with four different alkyl chain length (C0810, C0814, C1000, C1214) were contrasted. By Tafel extrapolation, the relevant electrochemical parameter was worked out by computer, listed in **Table 1**.

Table 1 Relevant electrochemical parameter

APG	The dosage of APG $mg \cdot L^{-1}$	E_∞/ mV	kath./$mV \cdot dec^{-1}$	Icorr./$uA \cdot cm^{-2}$	Z%
seawater		-720	-144	21.9	0
C0810	500	-647	-136	12.1	44.75
C0814	500	-593	-127	15.3	30.14
C1000	500	-604	-143	16.3	25.57
C1012	500	-551	-144	16.1	26.48

Remark: E_∞ means the open circuit potential of work electrode in seawater (the same as below)

Contrasted with the open circuit potential of seawater, the open circuit potential of C0810 system was transferred to cathodic area, through which the conclusion could be drawn that C0810 was cathodic-type inhibitor. The data in **Table 2** suggested that C0810 could restrain the corrosion of carbon steel well, but C0814, C1000, C1214 could hardly protect the carbon steel in seawater.

The study of synergistic effect of the compound inhibitors

According to the reports and references, both calcuim gluconate and zinc sulfate can protect carbon steel from being eroded, their best ratio is 1:2[5]. Therefore, in order to reduce the dosage of APG and study the synergistic effect, 100 $mg \bullet L^{-1}$ calcuim gluconate and 200 $mg \bullet L^{-1}$ zinc sulfate were added into seawater together with 200 $mg \bullet L^{-1}$ APG(C0810). Potentiodynamic polarization experiments were also carried out. The curves are shown in **Figure 1** and their parameter are listed in **Table 2**.

Figure 1 shows that compound inhibitors change the open circuit potential slightly, this result indicated that the compound inhibitor may be the corrosion inhibitor of mixed-type. But calcuim gluconate is anodic-type inhibitor, APG and zinc sulfate are cathodic-type inhibitor. After inhibitors were mixed, the potentiodynamic polarization curves of the compound inhibitor are ideal. It indicates that the reaction resistance of the anodic area and the cathodic area have both increased. There is a broad flat area on the anodic polarization curves, which is often considered for the steel having been passivated, and formed an inhibitor film.

Figure 1 Potentiodynamic polarization curves of single regent and compound inhibitors

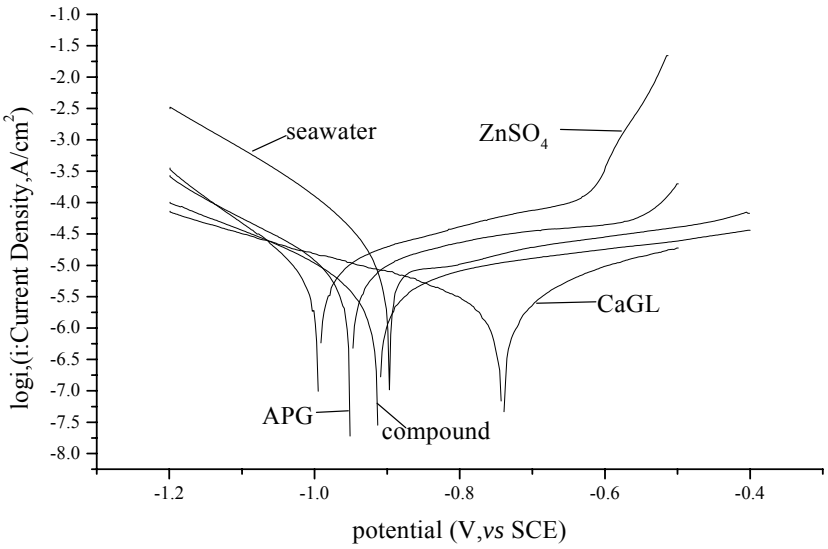

Table 2 Relevant electrochemical parameter

Inhibitor	The dosage of inhibitor /mg·L^{-1}	Ecorr/mV	Icorr./uA·cm^{-2}	Z%	kath./mV·dec^{-1}
seawater		-918.5	21.9	0	-144
APG-C0810	500	-960.8	12.1	44.75	-136
$ZnSO_4$	500	-992.5	10.3	52.97	-142
CaGL	500	-732.4	9.7	55.71	-118
Compound	500	-926.5	7.14	67.40	-123

Table 3 shows the best corrosion inhibitor for the carbon steel in seawater . The result can be interpreted as below: This corrosion inhibitor can form an adsorbent film and a deposit film. But the adsorbent film acts primarily. The reason is that Zn^{2+} combined with the OH^- from the cathodic area formed $Zn(OH)_2$ deposit film. This deposit film can prevent O_2 from diffusing to cathodic area and protect the mild steel. In corrosion inhibitor-seawater solution, the polar part of APG molecules bonded on the surface of bare metal and formed a tri-coordinate adsorptive film slowly. It is not close-grained enough to protect the steel entirely. But with the help of calcium gluconate, its protection efficiency becomes much better. And the efficiency of the combined corrosion inhibitor is improved greatly.

Validate the electrochemical results by weight-loss trials. The experiment process was as above related. And its result is listed in **Table 3**.

From **Table 3**, the weight loss of 907 carbon steel in seawater is 120.0 mg, and that is only 4.6 mg in seawater with corresponding inhibitor. The corrosion rate of the 907 carbon steel in seawater with the inhibitor is much lower than that of without the inhibitor in seawater.

Table 3 The results of weight-loss

The dosage of inhibitor /mg·L^{-1}	Weight loss /mg	Experiment time /d	Corrosion rate /g·m^{-2}·d^{-1}	Inhibition rate /Z%
Seawater	120.0	7	1.92	0
APG(C0810) 100				
CaGL 200	4.6	7	0.073	96.2
$ZnSO_4$ 200				

Judged from the result of weight-loss experiments, the inhibition rate has been improved greatly. The immersed time of weight-loss (7d) was much longer than that of potentiodynamic polarization. Because potentiodynamic polarization is strong, which would change the surface state of the carbon steel electrode seriously[6]. The weight-loss results should be regarded as the standard way to evaluate the inhibition rate of different inhibitors.

Conclusion

In the present study, the corrosion behavior of 907 carbon steel in natural seawater was studied by potential polarization curves measurements and weight-loss trials, respectively. The results are as follows.

The green surfactant APG can inhibit the corrosion of 907 carbon steel in quiescent, natural seawater. The inhibitory effect is different, if the alkyl chain length of APG is different. Among them, C0810 has the best inhibition.

When APG combined with calcuim gluconate and zinc sulfate, the corrosion inhibition rate was improved greatly, although the dosage of APG had been reduced largely. The distinct synergistic effect was found among APG, calcuim gluconate and zinc sulfate.

The corrosion inhibitor was found to control both the anodic and the cathodic processes, suggesting that it may be the corrosion inhibitor of mixed-type. This corrosion inhibitor could form an adsorbent and deposited film on the surface of the metal. But the adsorbent film acted primarily.

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