Corrosion resistance of API X70 pipeline in glutaraldeyde, and sodium sulfite and hydroxide

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Introduction

A practice used to prevent corrosion in mining is the hibernation of pipelines with an aqueous solution, usually of river water, containing corrosion inhibitors and biocides in the previous step to the beginning of the mining operation. Among the non-oxidizing biocides are formaldehyde, glutaraldehyde, isothiazolones, and quaternary ammonium compounds [1]. Substances which promote the increase of pH, such as sodium hydroxide, and are oxygen scavengers, such as hydrazine, are also considered biocides, even if not the main function of these substances. Glutaraldehyde acts only as a biocide. It is capable of reacting chemically with the cell membrane proteins killing of microorganisms rapidly from a minimum concentration of biocide active. Corrosion inhibitors commonly used that sequestrate oxygen are hydrazine and sodium sulfite [2].

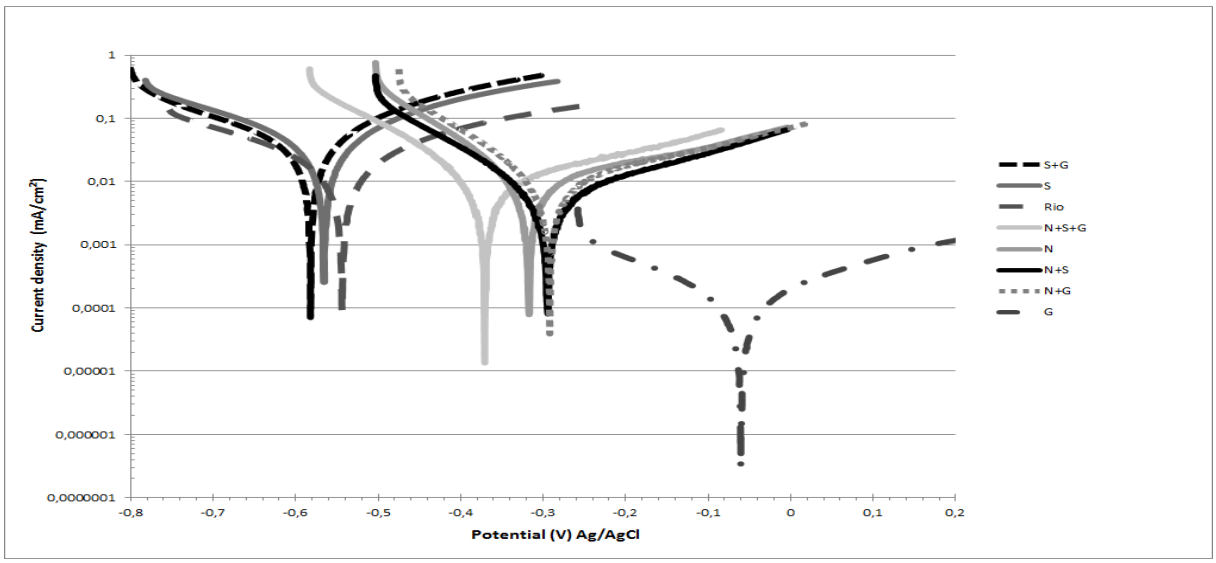
Experimental

Samples of API 5L X70 steel of 2.5 in length, 2.5 cm in width, and 1 cm in thickness were used. The API X70 steel contains 0.24% m/m of carbon and 1.40% m/m of manganese.

The seven electrolytes used were aqueous solutions of river water and glutaraldehyde (G), river water and sodium sulfite (S), river water and sodium hydroxide (N), river water, glutaraldehyde and sodium sulfite (G + S), river water, glutaraldehyde and sodium hydroxide (G + N), river water, sodium sulfite and hydroxide (S + N), and river water, glutaraldehyde, sodium sulfite and hydroxide (G+ S + N). The content of sodium hydroxide was 2000ppm, the content of sodium sulfite was 150ppm, and 70ppm of glutaraldehyde was used. The Tafel analysis was performed with 250mV polarization in relation to the corrosion potential, and with a scan rate of 0.167mV/s. The electrochemical impedance spectroscopy was performed by using potential amplitude of 10mV and frequency range of 100KHz to 1MHz. The potentiostat used is a Princeton VersaStat, with the reference electrode of silver/silver chloride and the counter electrode of platinum. The EIS results were analyzed by using the ZSim EchemSoftware.

Results and Discussion

The polarization curves obtained by using Tafel analysis are shown in Figure 1.



The electrochemical parameters obtained by using Tafel analysis and electrochemical impedance spectroscopy are shown in Table 1.

Table 1 – Electrochemical parameters

Electrolyte	Corrosion potential $(mV)_{Ag/AgCl}$	Corrosion current density $(\mu A/cm^2)$	Rp $(k\Omega.cm^2)$
G	-61	0.035	3841.1
N+G	-291	1.854	50.8
N+S	-294	1.179	5.9
N	-314	1.918	39.7
N+S+G	-370	1.990	27.6
River water	-543	7.610	9.3
S	-565	14.579	5.7
S+G	-581	13.510	4.3

The highest corrosion resistance of API X70 steel was observed in the solution of glutaraldeyde in river water. The API X70 steel showed the highest corrosion potential and polarization resistance and the lowest corrosion current in the glutaraldehyde aqueous solution. The glutaraldehyde have two unsaturated C=O end-groups that can join FeOOH molecules to produce a protective layer consisting of chains of glutaraldehyde and iron hydroxide. During the electrochemical test, there was no time to the reaction of glutaraldehyde and organic matter present in river water. Then, the glutaraldehyde can adsorb on the surface of steel and reacts with iron hydroxide. For a longer immersion time of steel in glutaraldehyde solution, the stability of glutaraldehyde in aqueous solution and the reaction between the compound and organic matter must be considered. The electrolytes containing sodium hydroxide showed pH 12 and the API X70 steel showed intermediate values of polarization resistance in these environments. The lowest corrosion resistance of API X70 steel was obtained in media containing sulfite. The pH of

solutions containing sulfite (S) and sulfite and glutaraldehyde (S+G) was 5, and the pH of the river water was 6. The lower value of pH contributes to the lower corrosion resistance of steel in these media. In river water solution containing sulfite and glutaraldeyde, the polarization resistance was lower than in medium containing only glutaraldeyde due to the reaction between glutaraldehyde and sodium sulfite. The sodium sulfite reacts with glutaraldehyde, producing sodium hydroxide and glutaraldehyde-bisulfite. The API steel in hibernation solution (N+S +G) showed a polarization resistance three times the resistance of API X70 steel in river water, demonstrating the efficiency of the additives used. The Nyquist diagram of steel in the river water containing sodium hydroxide and glutaraldehyde, in river water and sodium hydroxide, and in river water showed one capacitive arc, with one time constant. The Nyquist diagram of steel in the others electrolytes showed two capacitive arcs. Figure 2 showed Nyquist diagram for the API steel in river water with addition of sodium hydroxide. The equivalent circuit is shown in Figure 3. Rs is the electrolyte resistance, and Rp is the polarization resistance at the steel/corrosion product interface.

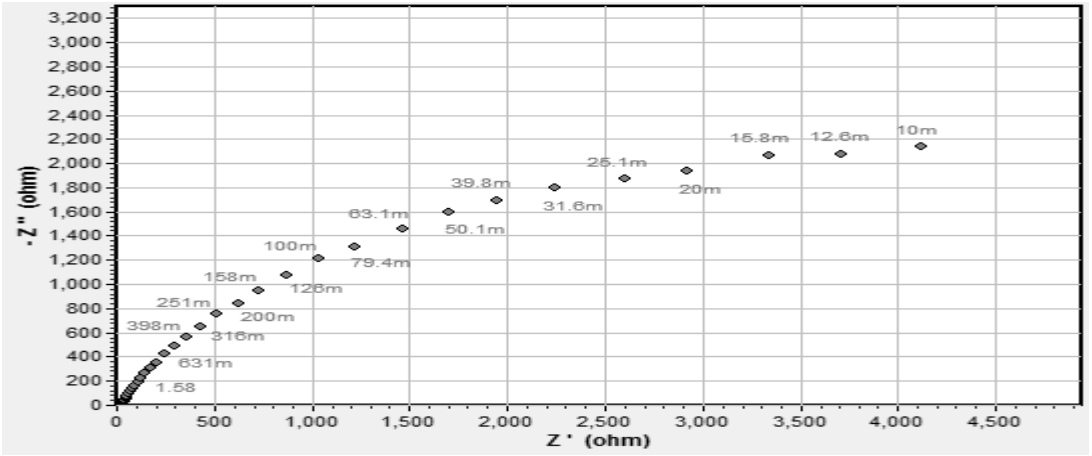


Figure 2 – Nyquist diagram for API X70 steel in river water with sodium hydroxide

Figure 3 – Equivalent electric circuit

Conclusions

The highest corrosion resistance of API X70 steel was observed in the solution of glutaraldehyde in river water. The API steel showed the highest corrosion potential and polarization resistance and the lowest corrosion current in this medium.

The lowest corrosion resistance of API X70 was obtained in media containing sulfite.

The API steel in hibernation solution (N+S +G) showed a polarization resistance three times the resistance of API X70 steel in river water, demonstrating the efficiency of the additives used.

Acknowledgements

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