Inhibition of corrosion of L 80 alloy pipeline carrying simulated oil well water by succinic acid

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ABSTRACT

Simulated oil well water (SOWW) is conceded out by pipelines made of several alloys, for instance mild steel L80. These alloys may simulated oil well water undergo corrosion owing to presence of various aggressive ions present in SOWW. To prevent this several inhibitors have been used. Inhibition of corrosion of L80 alloy pipeline carrying simulated oil well water by succinic acid has been evaluated by electrochemical studies such as polarization study and AC impedance spectra (EIS). Polarisation study reveals that in the presence of inhibitor linear polarization resistance increases and corrosion current decreases. AC impedance spectra reveal that in presence of succinic acid, R_t value increases, impedance value increases, phase angle increases and C_{dl} value decreases. The present study reveals that when succinic acid is added to simulated oil well water, the corrosion resistance of L80 alloy increases. It implies that succinic acid may be added to simulated oil well water flowing through pipe line made of L80 alloy.

Keywords: *Inhibition of corrosion, L80 alloy, pipeline carrying simulated oil well water , succinic acid , electrochemical studies.*

1. INTRODUCTION

Simulated oil well water (SOWW) is conceded out by pipelines made of several alloys for instance mild steel L80. These alloys may simulated oil well water undergo corrosion owing to presence of various aggressive ions present in SOWW. To prevent this several inhibitors have been used. Annular corrosion risk analysis of gas injection in CO2 flooding and development of oil-based annulus protection fluid has been done by Zeng et al.[1]. Bai et al. have investigated the effect of effect of thiourea imidazoline quaternary ammonium salt corrosion inhibitor on corrosion of X80 pipeline steel [2].

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Cardiospermum halicacabum leaves extract has been used as a green corrosion inhibitor for mild steel in simulated oil well water medium by Kavitha et al. [3]. Inhibition of corrosion of mild steel pipeline carrying simulated oil well water by Allium sativum (Garlic) extract has been reported by Joycee et al. [4]. Anti-corrosive properties of an aqueous extract of chrysanthemum indicum flower for simulated oil well water has been reported by Kavitha et al. [5]. Weight loss method and electrochemical measurements have been used. Prabha et al. have reported inhibition of corrosion of mild steel in simulated oil well water by an aqueous extract of Andrographis paniculata[6]. The findings have potential application in petroleum industry. The inhibitor extract can be added along with the simulated oil well water in the pipelines made of mild steel [6]. Zhao et al. have reported on an experimental study on the corrosion behavior of produced fluid on J55 steel during CO_2 flooding [7].

The research has a theoretical guiding significance on corrosion protection during CO_2 flooding. Potential of local pH control additives for corrosion inhibition in water base drilling fluids has been investigated by Aremu et al. [8]. It has been observed that cocoa pod extract is more stable thermally and is very effective reducers of filtration loss at high temperatures. Geethanjali and Subhashini have conducted an investigation of corrosion inhibition efficiency of somesynthesized water soluble terpolymers on N-80 steel in HCl, NaCl and simulated oil well water.The results provided a preliminary validation of the inhibitor such that theycan be optimised and used for corrosion in oil and gas industries [9]. Zhang et al. have reported an investigation of inhibition properties of sophorolipids for X65 steel corrosion in simulated oilfield produced water saturated with carbon dioxide.

Results demonstrated that sophorolipids showed good inhibition performance for X65 steel corrosion in simulated oilfield produced water saturated with CO_2 and was found to be an anodic-type inhibitor [10]. The present work is undertaken to investigate the inhibitive property of succinic acid in controlling corrosion of L80 alloy pipeline carrying simulated oil well water by electrochemical studies such as polarization technique and AC impedance spectra (EIS).

2. EXPERIMENTAL

L80 alloy chemical composition

Composition of L80 alloy is shown in Table 1.

Table 1. L80 alloy chemical composition

Tabela 1. Hemijski sastav legure L80

	C	Mn	Mo	Cr	Ni	Cu	Ti	P	S	Sii	V	Al
MIN.	-	-	-	-	-	-	-	-	-	-	-	-
MAX.	0.430	1.900	-	-	0.250	0.350	-	0.030	0.030	0.450	-	-

They are widely used in various industries, petroleum, construction, shipbuilding, smelting, aviation, electric power, food, paper, chemical industry and so on.

Preparation of Simulated Oil Well Water (SOWW)

In 100 mL of doubly distilled water, sodium chloride (3.5 g), calcium chloride (0.305 g) and magnesium chloride (0.186 g) are added. Just before experiment, add 0.067 g sodium sulfide and 0.4 mL of concentrated hydrochloric acid to generate hydrogen sulfide gas to form a simulated oil well water encompassing 100 ppm of H_2S.

Potentiodynamic Polarization Study

In the present exploration, polarization studies were carried out in a CHI Electrochemical work station/ analyzer, model 660A. It was provided with automatic *iR* compensation facility. A three electrode cell assembly was used.

The working electrode was L80 alloy. A saturated calomel electrode (SCE) was the reference electrode and platinum was the counter electrode.

From the polarization study, corrosion parameters such as corrosion potential (E_{corr}), corrosion current (I_{corr}) and Tafel slopes (anodic = b_a and cathodic = b_c) and linear polarization resistance (LPR) were calculated. LPR monitoring is an effective electrochemical method of measuring corrosion. Monitoring the relationship between electrochemical potential and current generated between electrically charged electrodes in a process stream allows the calculation of corrosion current. If the electrodes are corroding at high rate with the metal ions passing into solution, a small potential applied between the electrodes will produce a high current, and therefore a low polarization resistance. This corresponds to a high corrosion rate.

AC Impedance Spectra

The instrument used for polarization study was used to record AC impedance spectra also. The cell setup was also the same. The real part (Z') and imaginary part (-Z") of the cell impedance were measured in ohms at various frequencies. The details of the experimental conditions are as follows: Initial E (V) = 0; High frequency (Hz) = 1 x 10^5; Low frequency (Hz) = 10; Amplitude (V) = 0.005; Quiet Time (s) = 2. Values of the charge transfer resistance (R_t) and the double layer capacitance (C_{dl}) were calculated.

3. RESULTS AND DISCUSSION

Inhibition of corrosion of L80 alloy pipeline carrying simulated oil well water by succinic acid has been evaluated by exlectrochemical studies such as polarization study and AC impedance spectra (EIS) [11-30].

Polarization study

The polarization curves of L80 alloy immersed in various test solutions are shown in Figures 1-4. The corrosion parameters namely corrosion potential (E_{corr}), corrosion current (I_{corr}) and Tafel slopes (anodic = b_a and cathodic = b_c) corrosion current (I_{corr}) and linear polarization resistance (LPR) were calculated.

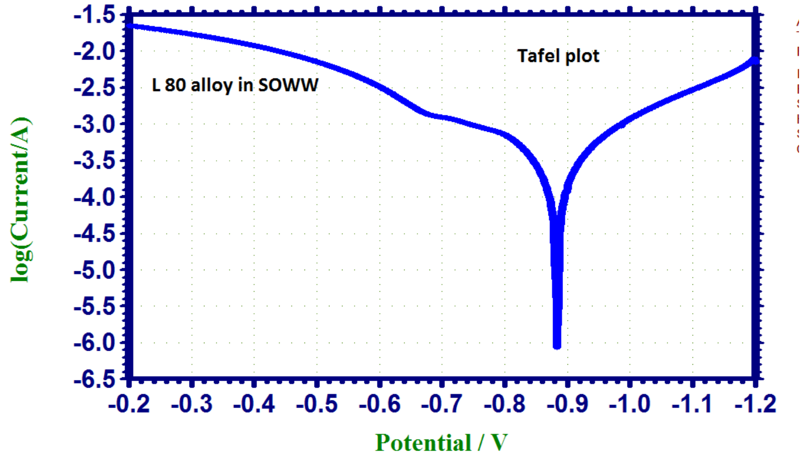

Figure 1. Polarisation curve of L 80 alloy immersed in SOWW

Slika 1. Kriva polarizacije legure L 80 uronjene u SOWW

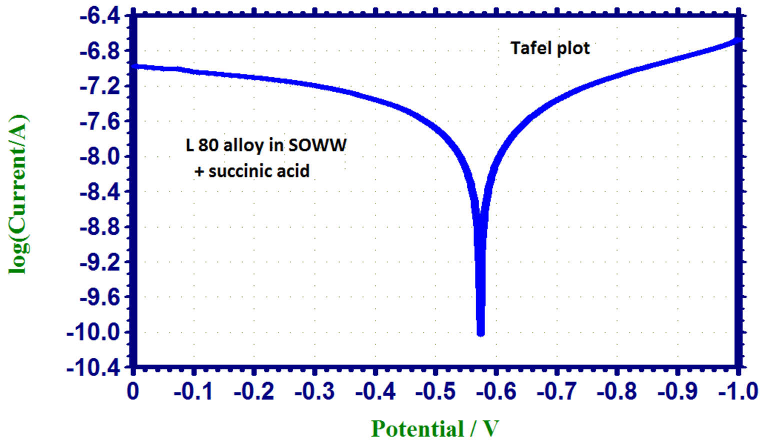

Figure 2. Polarisation curve of L 80 alloy immersed in SOWW + succinic acid

Slika 2. Kriva polarizacije legure L 80 uronjene u SOWW + ćilibarna kiselina

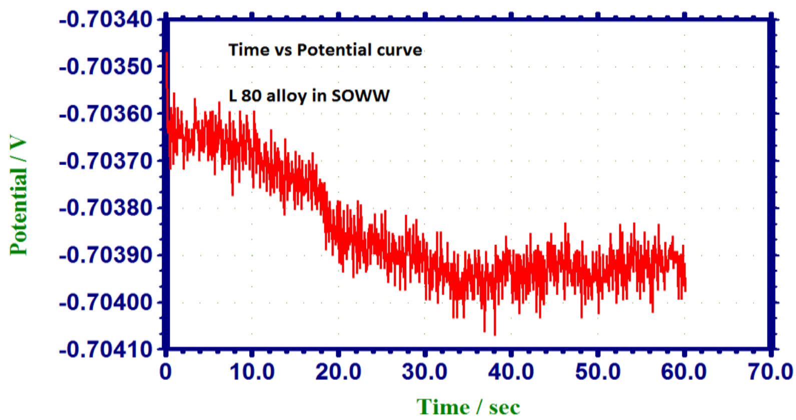

Figure 3. Time vs potential curve of L 80 alloy immersed in SOWW

Slika 3. Kriva vremena u odnosu na potencijal legure L 80 uronjene u SOWW

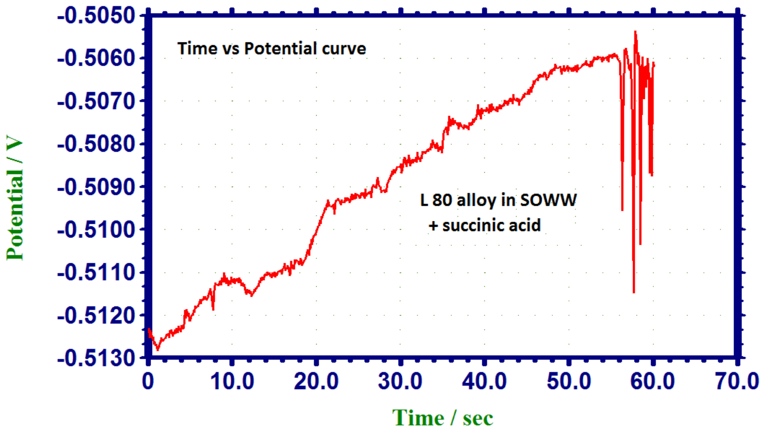

Figure 4. Time vs potential curve of L 80 alloy immersed in SOWW + succinic acid

Slika 4. Kriva vremena u odnosu na potencijal legure L 80 uronjene u SOWW + ćilibarna kiselina

The corrosion parameters are given in Table 2. In polarization study, when corrosion resistance increases, LPR increases and corrosion current decreases.

Table 2. Corrosion Parametres of L80 alloy immersed in various test obtained by Polarisation study

Tabela 2. Parametri korozije legure L80 potopljene u različitim testovima dobijenim polarizacionom studijom

System	E_{corr} mV/SCE	b_c mV/decade	b_a mV/decade	LPR Ohm cm^2	I_{corr} A/cm^2
SOWW	-884	170	261	123	$3.572x10^{-4}$
SOWW + succinic acidd	-574	185	222	3203607	$1.369x10^{-9}$

It is observed from Table 2, that in the presence of inhibitor corrosion resistance of L80 alloy increases. This is revealed by the fact that in the presence of inhibitor LPR increases and corrosion current decreases.

AC impedance spectra

The AC impedance spectra of L80 alloy in simulated oil well water (SOWW), in the absence and presence of 100 ppm of succinic acid are shown in Figures 5-10. The Nyguist plots are shown in Figures 5,6. The Bode plots are shown in Figures 8 and 9. The interactive 3D plots are shown in Figures 7and 10 .

The corrosion parameters such as charge transfer resistance (R_t), impedance value, phase angle values and double layer capacitance (C_{dl}) values are given in Table 2.

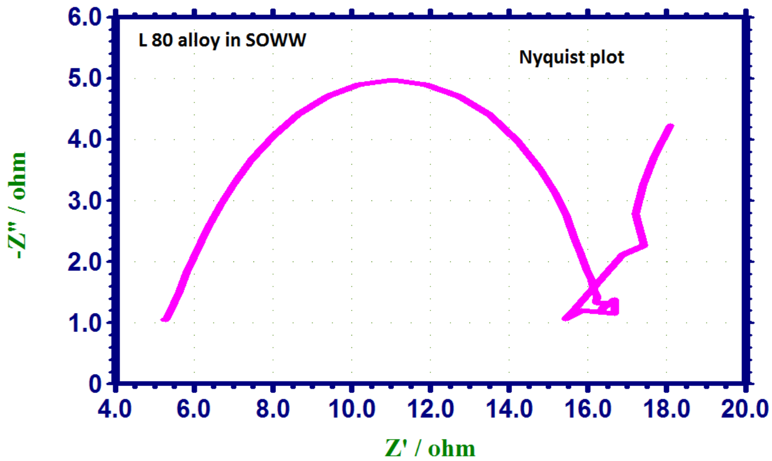

Figure 5. Nyquist plot of L 80 alloy immersed in SOWW

Slika 5. Nyquist-ova kriva legure L 80 uronjena u SOWW

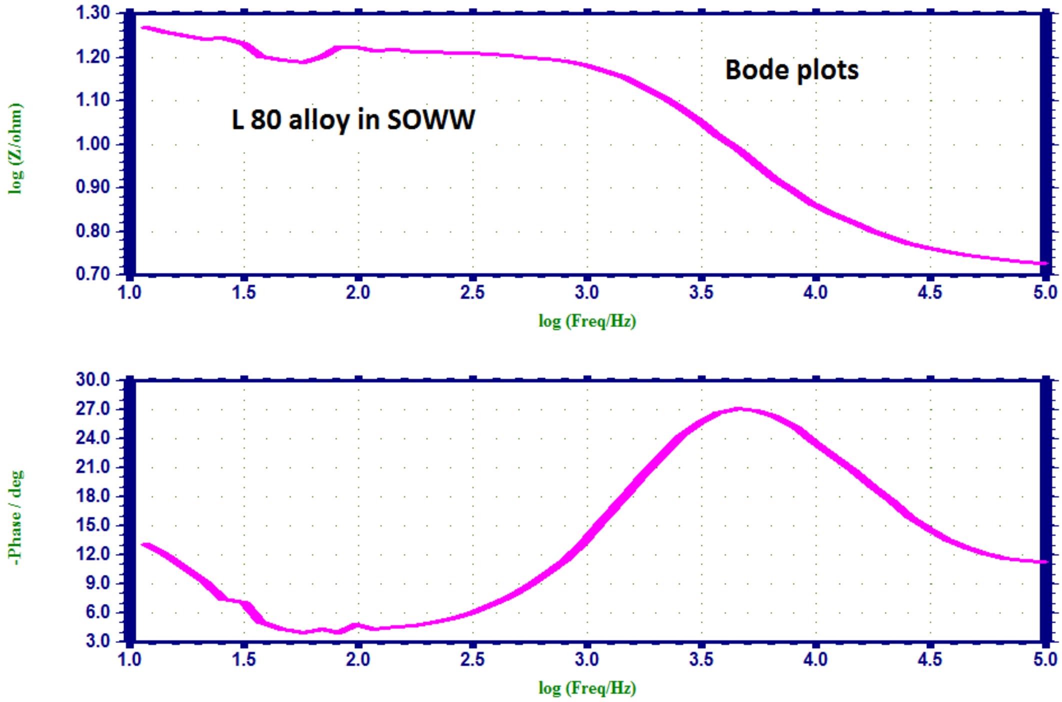

Figure 6. Bode plots of L 80 alloy immersed in SOWW

Slika 6. Bode-ove krive legure L 80 uronjena u SOWW

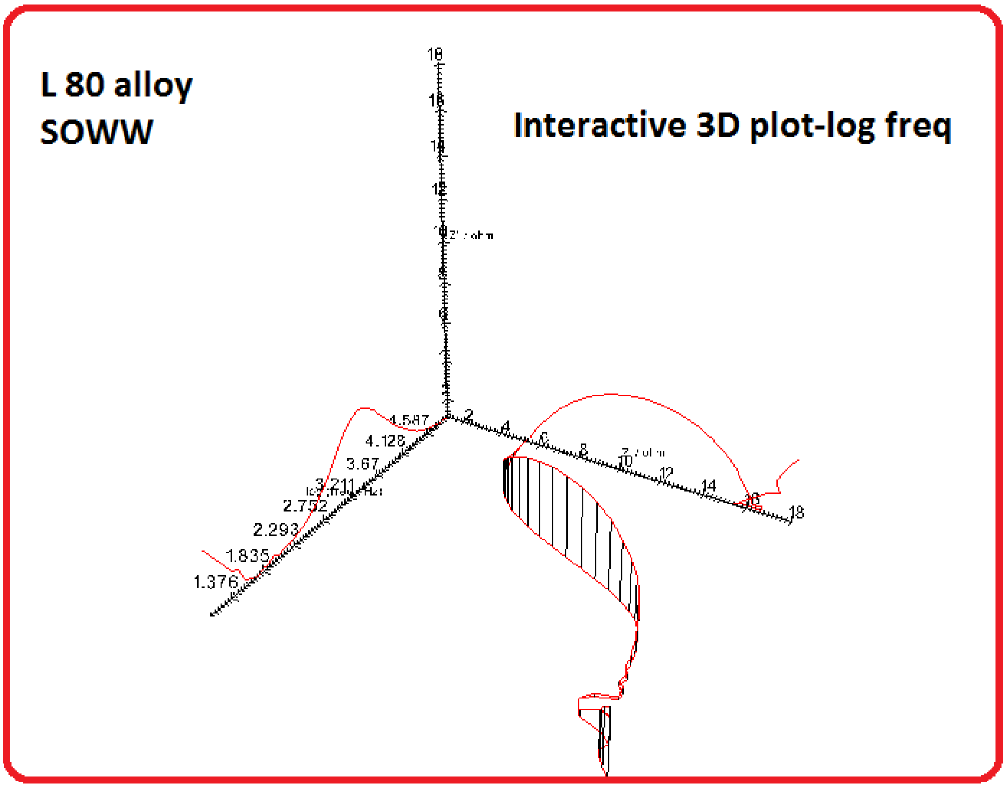

Figure 7. Interactive 3D plot of L 80 alloy immersed in SOWW

Slika 7. Interaktivni 3D prikaz legure L 80 uronjen u SOWW

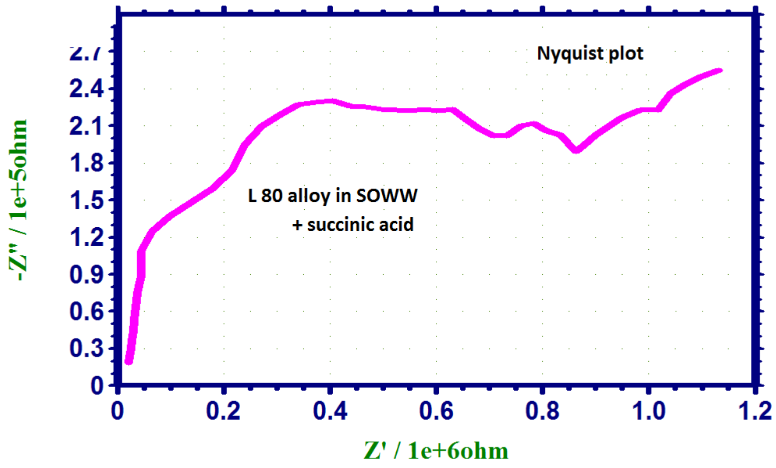

Figure 8. Nyquist plot of L 80 alloy immersed in SOWW + succinic acid

Slika 8. Nyquist-ova kriva legure L 80 uronjena u SOWW + ćilibarna kiselina

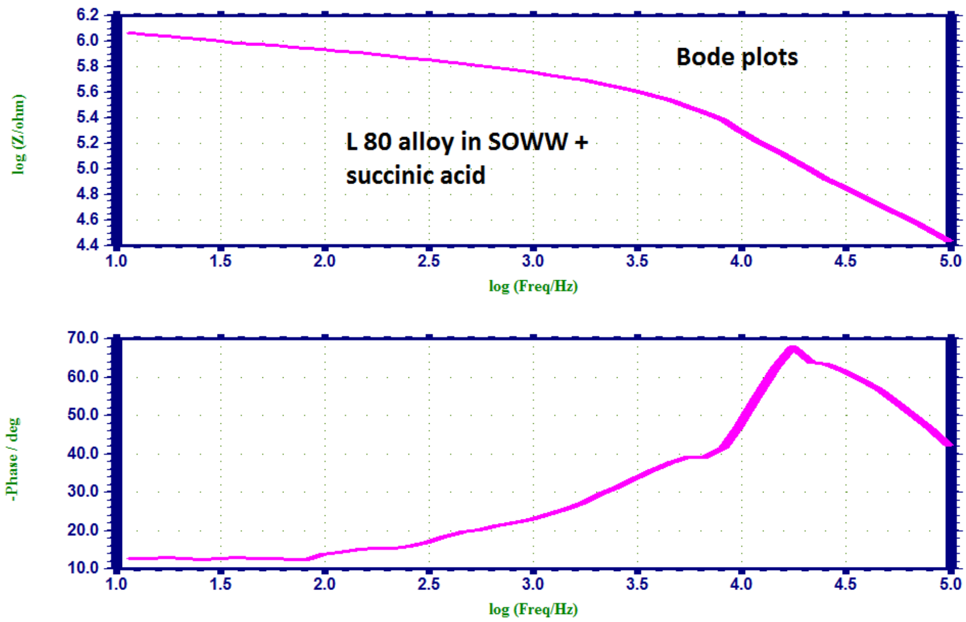

Figure 9. Bode plots of L 80 alloy immersed in SOWW + succinic acid

Slika 9. Bode-ove krive legure L 80 uronjena u SOWW + ćilibarna kiselina

In AC impedance spectra analysis, when corrosion resistance increases, R_t values and impedance values increase whereas C_{dl} values decrease.

It is observed from Table 3, that in presence of 100 ppm of succinic acid , the corrosion resistance of L80 alloy in SOWW increases. This is revealed by the fact that in presence of succinic acid, R_t value increases, impedance value increases, phase angle increases and C_{dl} value decreases.

Table 3. Corrosion Parametres of L80 alloy immersed in various test obtained by AC Impedance spectra

Tabela 3. Parametri korozije legure L80 uronjene u različitim rastvorima dobijene spektrom impedanse naizmenične struje

System	R_t, Ohmcm^2	C_{dl}, F/cm^2	Impedance, Log(Z/ohm)	Phase angle°
SOWW	13	3.92×10^{-7}	1.265	27
SOWW + succinic acidd	1133208	4.50×10^{-12}	6.066	68

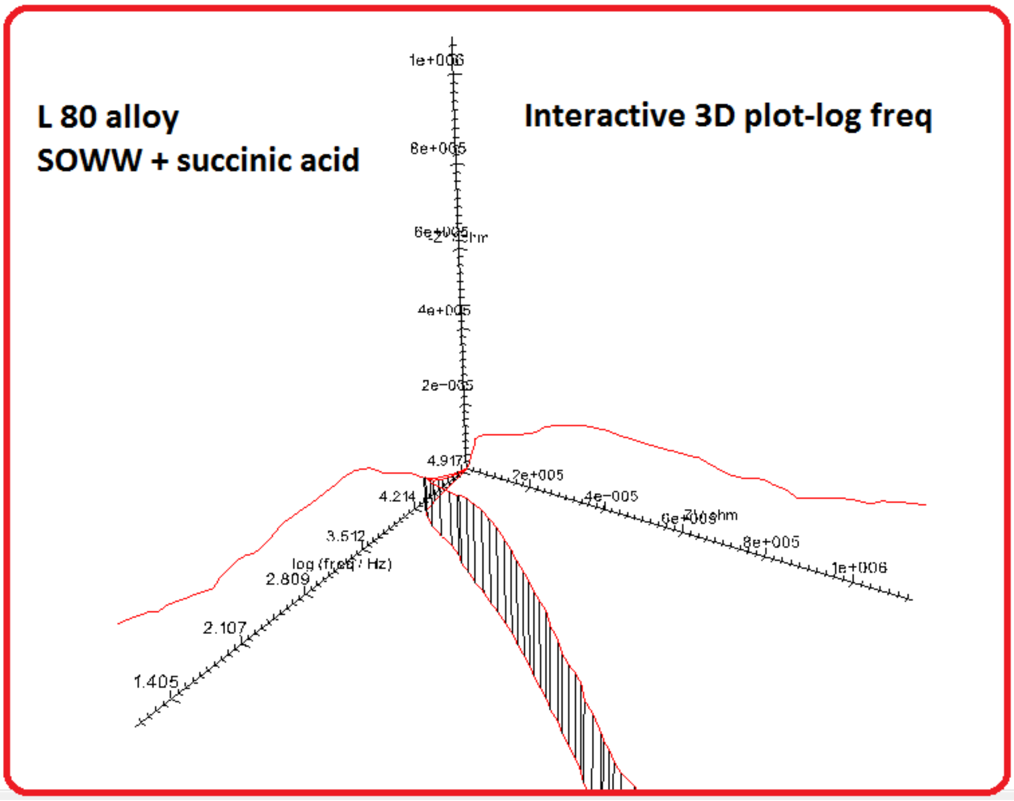

Figure10. Interactive 3D plot of L 80 alloy immersed in SOWW + succinic acid

Slika 10. Interaktivni 3D prikaz legure L 80 uronjen u SOWW + ćilibarna kiselina

Implication

The present study reveals that when succinic acid is added to simulated oil well water, the corrosion resistance of l80 alloy increases. It implies that succinic acid may be added to simulated oil well water flowing through pipe line made of L80 alloy.

4. CONCLUSIONS

- Inhibition of corrosion of L80 alloy pipeline carrying simulated oil well water by succinic acid has been evaluated by exlectrochemical studies such as polarization study and AC impedance spectra (EIS).
- Polarisation study reveals that in the presence of inhibitor LPR increases and corrosion current decreases.
- AC impedance spectra reveal that in presence of succinic acid, R_t value increases, impedance value increases, phase angle increases and C_{dl} value decreases.
- The present study reveals that when succinic acid is added to simulated oil well water, the corrosion resistance of l80 alloy increases.
- It implies that succinic acid may be added to simulated oil well water flowing through pipe line made of l80 alloy.

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IZVOD

INHIBICIJA KOROZIJE CEVOVODA OD LEGURE L 80, KOJI NOSI SIMULIRANU VODU IZ BUNARA, ĆILIBARNOM KISELINOM

Voda iz naftne bušotine (SOWW) ispušta se cevovodima napravljenim od nekoliko legura, na primer mekog čelika L80. Ove legure mogu, ispuštajući vodu iz naftnih bunara, da podležu koroziji zbog prisustva različitih agresivnih jona prisutnih u vodi iz naftne bušotine (SOWW). Da bi se ovo sprečilo, korišćeno je nekoliko inhibitora. Inhibicija korozije cevovoda od legure L80, koji nosi simuliranu vodu iz bunara, ćilibarnom kiselinom je procenjena elektrohemijskim studijama kao što su studija polarizacije i spektri AC impedanse (EIS). Studija polarizacije otkriva da u prisustvu inhibitora raste otpor linearne polarizacije, a struja korozije opada. Spektri impedanse naizmenične struje otkrivaju da u prisustvu ćilibarne kiseline, vrednost R_t raste, vrednost impedanse raste, fazni ugao raste i vrednost C_{dl} opada. Ova studija otkriva da kada se ćilibarna kiselina doda simuliranoj vodi iz naftnih bunara, otpornost legure L80 na koroziju se povećava. To implicira da se ćilibarna kiselina može dodati simuliranoj vodi iz naftnih bunara koja teče kroz cevovod od legure L80.
***Ključne reči**: Inhibicija korozije, legura L80, cevovod koji nosi simuliranu bušotinsku vodu, jantarna kiselina, elektrohemijska ispitivanja.*

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