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The Effect of Imidazole with Mono Valent Cation for Corrosion and Biocidal Studies of Mild Steel in Acid Medium

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ABSTRACT

In this study, the imidazole was studied as a corrosion inhibitor. The inhibitory impact of Imidazole (IZ) in combination with Ag^+ (monovalent) on Mild steel in 0.1 N HCl has been studied. The weight loss method's outcomes, polarization study, and AC impedance measurements are used to determine the mechanistic characteristics of corrosion inhibitors. The weight loss investigation found that a formulation containing 300 ppm IZ and 30 ppm Ag^+ has an Inhibition efficiency (IE) of 89 percent in controlling Mild steel corrosion in 0.1 N HCl. Between IZ and Ag^+ , there is a synergistic effect.

Key words: Inhibitors, Corrosion, Imidazole, Polarization study, Synergistic effect

A chemical compound that retards or prevents a reaction is known as an inhibitor. In neutral aqueous solutions, a wide range of compounds can suppress metal corrosion, from ions like nitrate to polymers like polymer substances. Corrosion inhibitors can be either organic or inorganic. These inhibitors can be utilized alone or in a mixture with other compounds to provide synergy in the inhibition process. The selection and usage of inhibitors is governed by health and safety concerns. Organic inhibitors such as heterocyclic compounds operate on the anodes to limit corrosion in neutral aqueous solutions. In aqueous medium, metallic cations such as Ag^+ can also operate as cathodic inhibitors [1].

MATERIALS AND METHODS

Preparation of Imidazole

In a standard measuring flask, in double distilled water, 1 g of imidazole was dissolved neutralized, and then transferred to 100 mL. This solution was diluted to 100 mL from 1 mL, obtaining 100 ppm of Imidazole.

Preparation HCl solution

To make 0.1 M HCL, 8.18 ml of 37.5 percent

concentrated HCL was diluted in double distilled water and diluted by 250 ml SMF.

Preparation of silver Sulphate solution

In a standard measuring flask 1.07 g of silver sulphate was diluted in 250 mL of double distilled water. A hundred-fold dilution provides a concentration of Ag^+ ions of exactly 10 ppm.

Weighing the specimens before and immersion

A Denver instrument from Germany was used to weigh the mild steel specimens before and after immersion.

Determination of biocidal efficiency of the system

The most effective inhibitor formulation for corrosion Inhibition was chosen. The biocidal efficacy of biocides like N-cetyl-N, N, N-trimethyl ammonium bromide (CTAB) was investigated. CTAB was added in various concentrations to the inhibitor system formulation, including (50 ppm to 300 ppm). Carbon steel specimens that had been polished and degreased in duplicate were immersed in various conditions for seven days.

Characterization

Using a three-electrode cell assembly, impedance and Polarization analysis were performed in an Electrochemical Impedance Analyzer type CHI 660A.

RESULTS AND DISCUSSION

Weight loss method

Data depicted in (Table 1) shows the corrosion Inhibition efficiency (IE) and corrosion rates of IZ derived

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by weight-loss method in maintain the corrosion of mild steel soaked in 0.1 N HCl for one hour in the absence and presence of Ag⁺. The efficiency of inhibition improves as the inhibitor concentration rises [2-4].

Table 1 Inhibition efficiency (IE) of IZ–Ag⁺ system in resisting the corrosion of mild steel soaked in 0.1 N HCl for a period of one hour

Inhibition system: IZ–Ag ⁺					Immersion period: 1 hour			
IZ (ppm)	Ag ⁺ (0 ppm)		Ag ⁺ (10 ppm)		Ag ⁺ (20 ppm)		Ag ⁺ (30 ppm)	
	IE (%)	C.R (mmpy)	IE (%)	C.R (mmpy)	IE (%)	C.R (mmpy)	IE (%)	C.R (mmpy)
0	–	0.0806	8	0.0742	14	0.0693	21	0.0637
50	11	0.0717	19	0.0653	27	0.0588	40	0.0484
100	16	0.0677	26	0.0596	39	0.0492	54	0.0371
150	21	0.0637	31	0.0556	47	0.0427	69	0.0250
200	24	0.0613	38	0.0500	56	0.0355	79	0.0169
250	28	0.0580	43	0.0459	65	0.0282	84	0.0129
300	32	0.0548	48	0.0419	71	0.0234	89	0.0089

Synergism parameter (S_I)

The synergism parameter (S_I) is used to determine the synergistic effect that exists between chosen inhibitors. This parameter (S_I) could be determined using Aramaki and Heckermann's relationship.

$$S_I = 1 - I_{1+2} / 1 - I'_{1+2}$$

Where;

I₁₊₂ = (I₁+I₂)- (I₁×I₂)

I₁ = Coverage on surface by inhibitor (IZ)

I₂ = Coverage on surface by inhibitor (Ag⁺)

I' ₁₊₂ = Total Coverage on surface by inhibitor (IZ + Ag⁺)

Where Surface coverage I = IE/100

When S_I > 1, synergistic effect exists among Chosen inhibitors. In the case of S_I < 1, negative interaction occurs among Chosen inhibitors, (i.e., CR increases). (Table 2-4) show the computed synergism parameter values for the IZ and Ag⁺ systems.

Table 2 Synergism parameter (S_I) for mild steel soaked in 0.1 N HCl with and without IZ–Ag⁺ systems (10 ppm)

Inhibition system: IZ–Ag ⁺			Immersion period: 1 hour	
IZ (ppm)	I ₁	I ₂ (Ag ⁺ - 10 ppm)	I' ₁₊₂	S _I
50	0.11	0.08	0.19	1.0000
100	0.16	0.08	0.26	1.0270
150	0.21	0.08	0.31	1.0290
200	0.24	0.08	0.38	1.0968
250	0.28	0.08	0.43	1.1228
300	0.32	0.08	0.48	1.1538

Table 3 Synergism parameter (S_I) for mild steel immersed in 0.1 N HCl with and without IZ–Ag⁺ systems (20 ppm)

Inhibition system: IZ–Ag ⁺			Immersion period: 1 hour	
IZ (ppm)	I ₁	I ₂ (Ag ⁺ - 20 ppm)	I' ₁₊₂	S _I
50	0.11	0.14	0.27	1.0274
100	0.16	0.14	0.39	1.1475
150	0.21	0.14	0.47	1.2264
200	0.24	0.14	0.56	1.4091
250	0.28	0.14	0.65	1.6571
300	0.32	0.14	0.71	1.8621

Table 4 Synergism parameter (S_I) for mild steel immersed in 0.1 N HCl in the absence and presence of IZ–Ag⁺ systems (30 ppm)

Inhibition system: IZ–Ag ⁺			Immersion period: 1 hour	
IZ (ppm)	I ₁	I ₂ (Ag ⁺ - 30 ppm)	I' ₁₊₂	S _I
50	0.11	0.21	0.40	1.1333
100	0.16	0.21	0.54	1.3696
150	0.21	0.21	0.69	1.8710
200	0.24	0.21	0.79	2.6190
250	0.28	0.21	0.84	3.1875
300	0.32	0.21	0.89	4.2727

Influence of immersion period on the IE of IZ–Ag⁺ system

Data in (Table 5) shows the effect of immersion time on the IE of IZ (300 ppm)-Ag⁺ (30 ppm). The IE is seen to diminish as the immersion period rises. This could be

because the protective film created on the coverage of the metal was dissolved by the aggressive chloride ions present in 0.1 N HCl as the immersion period increased, and thus IE decreased.

Table 5 Immersion period for the IE of IZ–Ag⁺ system

System	Immersion period (Hours)					
	1	2	3	4	5	6
0.1 N HClCR (mmpy)	0.0806	0.0982	0.1073	0.1107	0.1193	0.1297
0.1 N HCl + IZ (300ppm) + Ag ⁺ (30ppm) CR (mmpy)	0.0089	0.0167	0.02253	0.0277	0.0334	0.0389
IE %	89	83	79	75	72	70

Table 6 Influence of IZ–Ag⁺ system on the biocidal efficiency (BE) of N-cetyl-N,N,N-trimethyl ammonium bromide (CTAB)

IZ (ppm)	Ag ⁺ (ppm)	CTAB (ppm)	IE (%)	CR (mmpy)	Colony forming unit (CFU/ml)	Biocidal efficiency BE (%)
0	0	0	–	0.0806	276 × 10 ²	--
300	30	0	89	0.0089	80 × 10 ²	71
300	30	50	86	0.0113	39 × 10 ²	86
300	30	100	87	0.0105	19 × 10 ²	93
300	30	150	85	0.0121	6 × 10 ²	98
300	30	200	83	0.0137	Nil	100
300	30	250	80	0.0161	Nil	100
300	30	300	76	0.0193	Nil	100

Influence of N-cetyl-N, N, N-trimethylammonium bromide (CTAB) on inhibition efficiency (IE) of IZ– Ag⁺ system

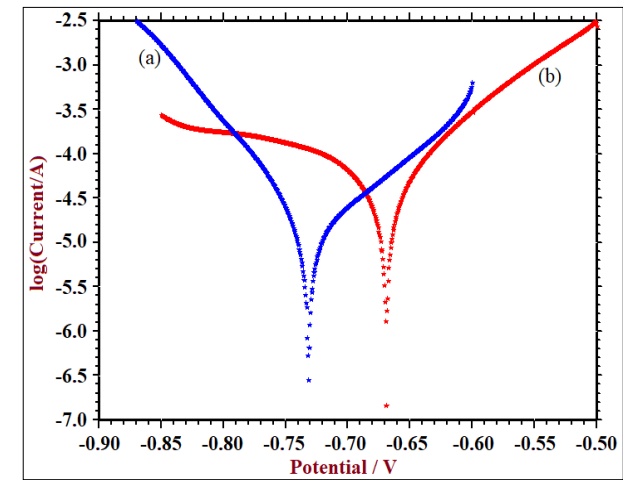
A cationic surfactant is N-cetyl-N, N, N-trimethylammonium bromide (CTAB). It's a biocide, after all. The data depicted in (Table 6) shows the Inhibition efficiency (IE) and biocidal efficiency (BE) of the IZ – Ag⁺ – CTAB system. The results show that using 150 ppm CTAB in associate with the IZ – Ag⁺ system enhanced Inhibition efficiency (IE) from 93 percent to 98 percent. When the CTAB concentrations are increased from 100 ppm to 250 ppm, however, the Inhibition efficiency (IE) of the IZ – Ag⁺ system decreases. This is related to micelle production at greater surfactant concentrations [5-6].

Polarization curves for IZ – Ag⁺ combination

Data summarized in (Table 7) lists the corrosion characteristics determined, including corrosion potential (E_{corr}), Tafel slopes, linear polarization resistance (LPR), and corrosion current (I_{corr}). The polarization curves of mild steel soaked in 0.1 N HCl in the presence and absence of inhibitors are depicted in (Fig 1). The corrosion potential of mild steel soaked in 0.1 N HCl is – 733 mV when compared to a Saturated Calomel Electrode (SCE). The corrosion current is 6.1 × 10^{–4} A/cm². When IZ (300 ppm) and Ag⁺ (30 ppm) are added to the above system the corrosion potential is moved to the anodic side (from –733 mV to –669 mV) [7-9].

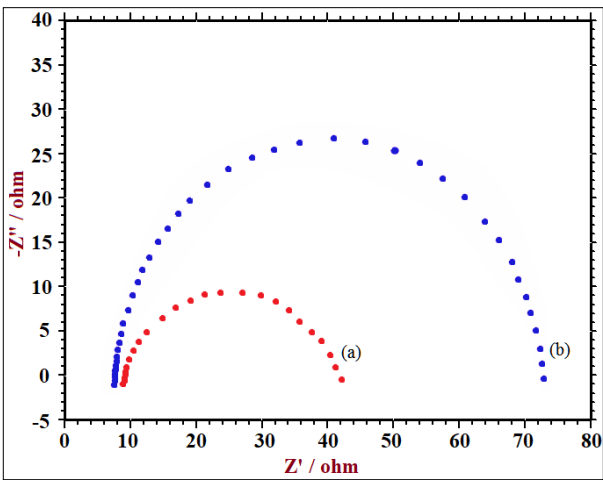
Table 7 Corrosion study of mild steel soaked in 0.1 N HCl with and without inhibitors obtained by polarization study

System	E _{corr} mV vs SCE	b _c mV/decade	b _a mV/decade	LPR Ω cm ²	I _{corr} A/cm ²
0.1 N HCl	– 733	230	130	36	6.1 × 10 ^{–4}
0.1 N HCl + 300 ppm IZ + 30 ppm Ag ⁺	– 669	116	260	34	4.1 × 10 ^{–4}



(a) 0.1 N HCl (blank)
(b) 0.1 N HCl + 300 ppm IZ + 30 ppm Ag⁺

Fig 1 Polarization study of mild steel soaked in various concentration



(a) 0.1 N HCl (blank)
(b) 0.1 N HCl + 300 ppm IZ + 30 ppm Ag⁺

Fig 2 Impedance study of mild steel soaked in various concentration (Nyquist plot)

Study of impedance for IZ – Ag⁺ system

Data in (Fig 2) shows the AC impedance spectra of mild steel soaked in 0.1 N HCl with and without inhibitors (a, b). The impedance system such as charge transfer resistance (Rt) and Double layer capacitance (Cdl). When mild steel is immersed in 0.1 N HCl, the Rt value is 34.4 cm² and the Cdl value is 4.1309 10⁻⁴ F/cm² When the inhibitor IZ and Ag⁺ are mixed to 0.1 N HCl, the Rt value raises from 34.4 cm² to 65.7 cm² (Table 8). This indicates that a surface coating forms on the metal surface [10].

Table 8 Impedance Study of Mild steel soaked in 0.1 N HCl with and without inhibitors obtained by impedance study

System	R _t Ω cm ²	Y _{max} Ω	C _{dl} F/cm ²
0.1 N HCl	34.4	11.2	4.1309 × 10 ⁻⁴
0.1 N HCl + 300 ppm IZ + 30 ppm Ag ⁺	65.7	29.1	0.8325 × 10 ⁻⁴

CONCLUSION

The weight loss investigation found that a formulation containing 300 ppm IZ and 30 ppm Ag⁺ has an IE of 89 percent in controlling Mild steel corrosion in 0.1 N HCl. Between IZ and Ag⁺, there is a synergistic effect. According to polarization studies, as a cathodic inhibitor, the IZ-Ag⁺ system is used. Primarily inhibiting the cathodic domination but also controlling the anodic response to some extent.

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