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XVI International Mineral Processing & Recycling Conference

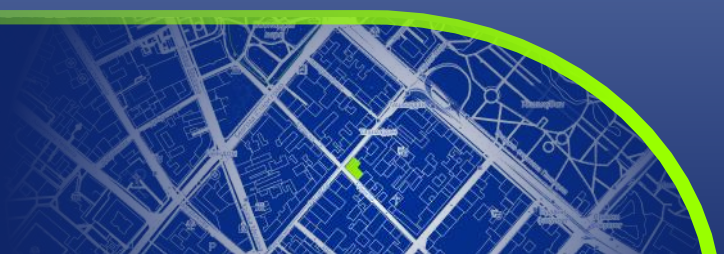
2025 IMPRC

INTERNATIONAL MINERAL PROCESSING & RECYCLING CONFERENCE

Proceedings

Editors:
Zoran ŠTIRBANOVIĆ
Milan TRUMIĆ

28-30 May 2025
Belgrade, Serbia



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INFLUENCE OF ORGANIC COMPOUND STRUCTURE ON BRASS CORROSION INHIBITION EFFICIENCY

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ABSTRACT – In this study the influence of organic compounds with different structures on the inhibition of brass corrosion in sodium chloride solutions of 0.9%, 2% and 3.5% is investigated. The experimental work includes the evaluation of the inhibition efficiency of 2-mercapto-1-methylimidazole (MMI), 2-amino-5-ethyl-1,3,4-thiadiazole (AETDA) and N-acetyl-L-leucine at various concentrations using electrochemical methods, including open circuit potential (OCP), cyclic voltammetry (CV), and potentiodynamic measurements (PD). The results show that all tested inhibitors reduce the corrosion currents and potentials, with the highest efficiency observed in solutions with the lowest sodium chloride concentration of 0.9%, where AETDA exhibited the highest inhibition efficiency of 92.93%, while MMI showed an efficiency of 88.78% at the same inhibitor concentration of 10^{-2} M. Compared to AETDA and MMI, N-acetyl-L-leucine at a concentration of 10^{-3} M showed the lowest inhibition efficiency of 44.21%, while AETDA and MMI achieved inhibition efficiencies of 76.12% and 72.16%, respectively. Adsorption isotherms were used to evaluate the binding mechanisms of inhibitors on the brass surface, and physisorption was found to be the most likely mechanism for all tested compounds. These findings provide insight into the potential application of the investigated inhibitors to prevent brass corrosion under corrosive conditions.

Keywords: Corrosion Inhibition, Brass, Electrochemical Methods, Sodium Chloride Solutions, Organic Inhibitors.

INTRODUCTION

Brass, an alloy of copper and zinc, is prone to corrosion in chloride-containing environments, leading to dezincification and structural degradation. Organic inhibitors, particularly those containing sulfur, nitrogen, and oxygen, have been widely studied for their ability to mitigate corrosion. The aim of this study is to evaluate the inhibition efficiency and adsorption behavior of three organic inhibitors (MMI, AETDA, and N-acetyl-L-leucine) in NaCl solutions of different concentrations [1, 2, 3, 4, 5].

EXPERIMENTAL

An brass electrode (Cu 70% - Zn 30%) was immersed in NaCl solutions (0.9%, 2.0%,

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and 3.5%) with different concentrations of inhibitors. Electrochemical measurements were performed using an electrochemical workstation with a three-electrode setup. OCP, CV, and PD techniques were employed to assess the inhibition efficiency. The Langmuir adsorption isotherm was applied to determine the adsorption mechanism [1, 2, 3, 4, 5].

RESULTS AND DISCUSSION

Open Circuit Potential (OCP) Measurements

OCP values, given on Figure 1, indicated a shift towards more positive potentials in the presence of inhibitors, suggesting reduced anodic dissolution. AETDA exhibited the most stable potential, indicative of strong surface adsorption [6, 7].

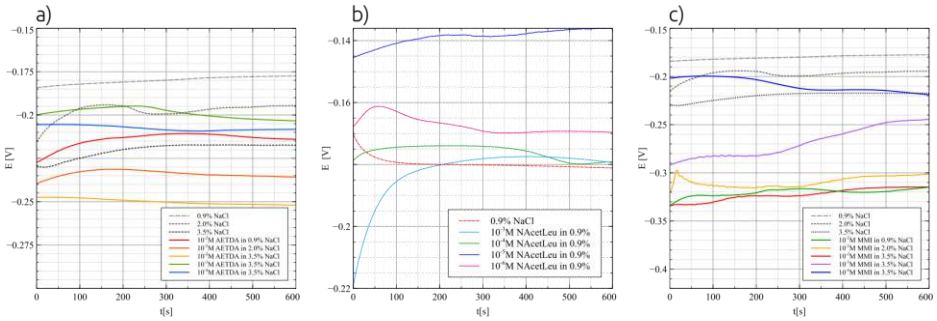

Figure 1 OCP valuers of AETDA a), N-acetyl-L-leucine b) and MMI c) for the measurement period of 10 minutes

Cyclic Voltammetry (CV)

Cyclic voltammetry was used to investigate the corrosion mechanism of brass in sodium chloride solutions of varying concentrations (0.9%, 2.0%, and 3.5%) and to evaluate the effect of three different inhibitors: MMI, AETDA and N-acetyl-L-leucine. In blank NaCl solutions, characteristic anodic and cathodic peaks were identified, corresponding to the oxidation and reduction of copper and zinc. In the presence of inhibitors, a reduction in current and a shift in peak potentials were observed, indicating inhibition of corrosion processes.

For MMI and AETDA, a significant decrease in peak intensities and narrowing of the voltammogram were noted, especially at higher inhibitor concentrations, suggesting effective surface protection of brass. N-acetyl-L-leucine showed weaker inhibition, with voltammograms resembling those of the uninhibited (blank) solutions. The voltammetric responses confirm that MMI and AETDA act as mixed-type inhibitors (inhibiting both anodic and cathodic reactions), while the effect of N-acetyl-L-leucine is more limited. The obtained voltammograms are represented on Figure 2 [1, 8, 9].

Potentiodynamic Polarization (PD)

Polarization curves demonstrated that AETDA provided the highest inhibition

efficiency, followed by MMI and N-acetyl-L-leucine. Corrosion potential (E_{corr}) shifted positively, and corrosion current density (j_{corr}) decreased in inhibited solutions, confirming the protective role of the inhibitors. Tafel extrapolation was used to determine electrochemical parameters, including the E_{corr} and j_{corr} for brass in solutions with and without added inhibitor which do to the length requirements were not represented in Table 1 but the IE% values were calculated using equation 1) [6, 10, 11].

$$IE(\%) = ((j_{kor} - j_{kor(inh)}) / j_{korr}) \cdot 100\% \quad (1)$$

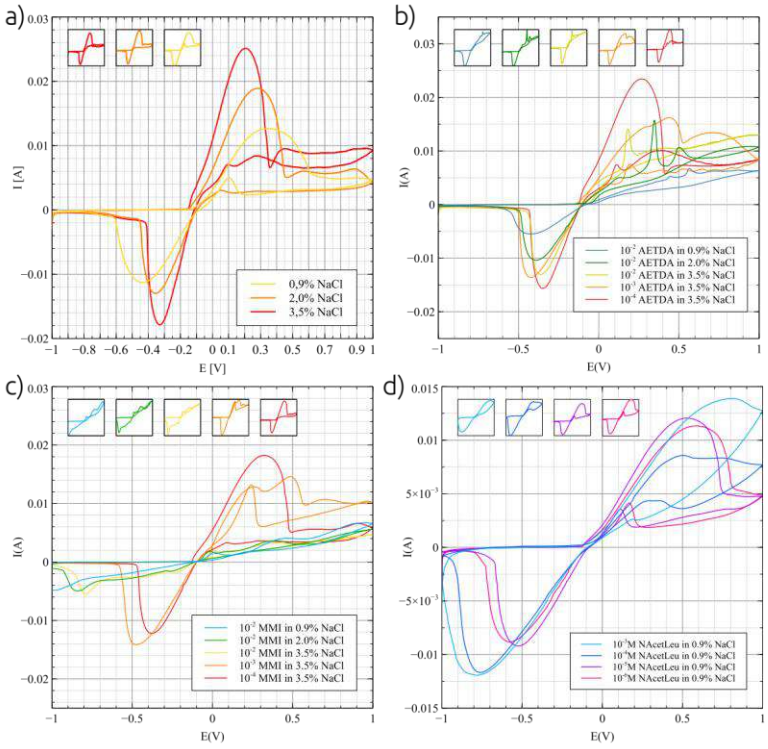

Figure 2 Cyclic voltammograms of brass imersed in a) the base (blank) solution, b) solutions with different amount of AETDA, c) solutions with different amounts of MMI and d) solution with different amount of N-acetyl-L-leucine

The results demonstrated that all inhibitors reduced the corrosion current density compared to the blank solution, indicating their effectiveness in suppressing corrosion processes. AETDA exhibited the highest inhibition efficiency of 92.93% in 0.9% NaCl, followed by MMI with 88.78%, while N-acetyl-L-leucine showed the weakest performance. The polarization curves revealed a shift in E_{corr} toward more positive values and a notable reduction in both anodic and cathodic current densities, suggesting that the inhibitors acted as mixed-type inhibitors [6, 10, 11].

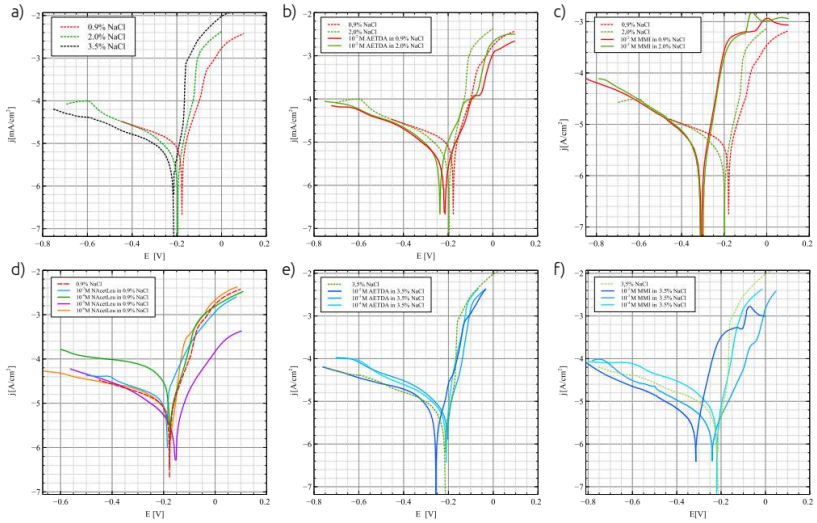

Figure 3 Polarization curves of brass in blank solutions and solutions with different amount of inhibitors

Adsorption Isotherm Analysis

The Langmuir adsorption isotherm, given on Figure 4, was applied to evaluate the interaction between inhibitors and the brass surface. The obtained values in Table 1. suggested physisorption as the predominant mechanism [12, 13].

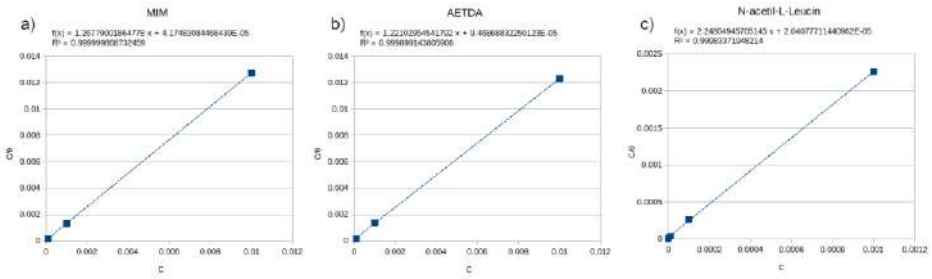

Figure 4 Langmuir adsorption isotherm for a) MMI, b) AETDA and c) N-acetyl-L-leucine

$$C/\theta = 1/K_{ads} + C \quad (2)$$

The isotherm is mathematically represented by the equation 2) where where C is the inhibitor concentration, θ is the surface coverage, and K_{ads} is the adsorption equilibrium constant. A linear plot of C/θ versus C allows for the determination of K_{ads}, where a higher value indicates stronger interaction between the inhibitor and the metal surface. The Gibbs free energy of adsorption ΔG_{ads} is calculated from equasion 3) [12, 13].

$$\Delta G = -RT\ln K_{ads} \quad (3)$$

Table 1 Inhibition efficiencies IE% and parameters obtained through Langmuir adsorption isotherm for the applied inhibitors

NaCl%	MMI			AETDA			N-acetyl-L-leucine			
	10^{-2}M	10^{-3}M	10^{-4}M	10^{-2}M	10^{-3}M	10^{-4}M	10^{-3}M	10^{-4}M	10^{-5}M	10^{-6}M
3.5%	78.62%	76.12%	60.19%	81.31%	72.16%	65.33%	/	/	/	/
2.0%	82.21%	/	/	89.99%	/	/	/	/	/	/
0.9%	88.78%	/	/	92.92%	/	/	44.21%	37.75%	25.98%	10.78%
θ	0.7862	0.7612	0.6019	0.8131	0.7216	0.6533	0.4412	0.3775	0.2598	0.1078
C/θ	$12.7\cdot10^{-3}$	$1.31\cdot10^{-3}$	$0.17\cdot10^{-3}$	$12.3\cdot10^{-3}$	$1.39\cdot10^{-3}$	$0.15\cdot10^{-3}$	$2.27\cdot10^{-3}$	$2.65\cdot10^{-4}$	$3.85\cdot10^{-5}$	$9.28\cdot10^{-6}$
R^2	0.9999			0.9998			0.9998			
ΔG	-23.9532 kJ/mol			-22.9545 kJ/mol			-26.7422 kJ/mol			

Values of ΔG_{ads} between -20 and -40 kJ/mol suggest physisorption, while values more negative than -40 kJ/mol suggest chemisorption. In this study, the Langmuir isotherm suggests physisorption for all applied inhibitors given their ΔG_{ads} values in Table 1 [12, 13].

CONCLUSION

The investigated inhibitors effectively reduced brass corrosion in chloride media. AETDA exhibited the highest inhibition efficiency, while N-acetyl-L-leucine showed the weakest performance. Making the order of inhibition efficiency AETDA > MMI > N-acetyl-L-leucine. Adsorption studies confirmed physisorption as the dominant mechanism for all inhibitors. These findings contribute to the understanding of organic inhibitors and their potential applications in corrosion protection strategies.

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