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School of Computer Science & Engineering

IILM University Greater Noida

Presents

1st National Conference

on

Technologies for Sustainable Development Goals 2025 (TECH4SDG-2025)

3rd March 2025

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INTERNATIONAL JOURNAL OF RESEARCH IN MODERN ENGINEERING & EMERGING TECHNOLOGY (IJRMEET)

Dear Author / Researcher,

On behalf of the *International Journal of Research in Modern Engineering & Emerging Technology (IJRMEET)*, I extend my heartfelt gratitude to all the authors and research scholars for choosing our platform to publish their valuable research contributions.

IJRMEET, a Refereed, Peer Reviewed, Indexed, and Monthly Journal in Electronic format, has been consistently dedicated since April 2013 to advancing scholarly work in the domains of Modern Engineering and Emerging Technologies. Your innovative and quality research is at the core of our mission to promote academic excellence and practical solutions in the ever-evolving field of engineering and technology.

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Our journal aims not only to disseminate high-quality research globally but also to highlight critical engineering problems and their practical resolutions. I encourage researchers, academicians, faculty members, and industry professionals to continue contributing to IJRMEET and to inspire their peers and students to join us in this academic pursuit.

We sincerely thank our respected Editors, Reviewers, Technical Advisors, Authors, Web Developers, Subscribers, Supporters, and the extended academic community whose efforts and encouragement make each issue of IJRMEET a successful endeavor.

With warm regards,

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डॉ. मोहम्मद रिहान / Dr. Mohammad Rihan
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MESSAGE

I am happy to know about Tech4SDG-2025, a distinguished national conference that aims to explore and highlight the transformative power of technology in achieving the United Nations Sustainable Development Goals (SDGs). This event serves as a critical platform for fostering collaboration among experts, innovators, and leaders who are dedicated to creating solutions that drive sustainable change.

As we face global challenges ranging from environmental sustainability to social equity, it is clear that technological advancements will play a pivotal role in shaping our collective future. Tech4SDG-2025 presents a unique opportunity to examine how cutting-edge technologies can contribute to solving the most pressing issues of our time, from climate change to poverty alleviation.

I look forward to the engaging discussions and innovative ideas that will emerge from this conference. I believe that by working together, we can harness the potential of technology to drive meaningful progress towards a sustainable and equitable world.

I extend my best wishes to all the participants and organizers of Tech4SDG-2025.

27.02.25

(Dr. Mohammad Rihan)

Dated: 27th February, 2025
Place: Gurugram

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A Study of the Corrosion Inhibition Properties of Glycine and Alanine on Metal Surfaces

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Abstract : Glycine and alanine present themselves as simple and useful molecules to explore the characteristics of amino-acid-based inhibition. Common to both compounds are an amino and a carboxyl group, while alanine has an additional methyl substituent. The study is focused on mild steel corrosion in 1.0 mol L−1 hydrochloric acid using gravimetry, potentiodynamic polarization, electrochemical impedance spectroscopy, and surface examination. Temperature effects will be investigated at 298 K and supplemented with measurements at 308 and 318 K. Preliminary numerical assumptions for a concentration of 10 mmol L−1 suggest polarization-based efficiencies of 68.0% for glycine and 72.0% for alanine. Respective gravimetric efficiencies after six hours amount to 66.3% and 70.0%. The numbers are offered as a framework for consistent reporting and do not claim to be empirical. The study distinguishes between protection against corrosion and direct measurement of adsorption, nor does it imply that natural occurrence proves environmental suitability. Application-based tests remain required before recommending any of the substances for metal protection.

Keywords: Glycine; alanine; corrosion inhibition; mild steel; hydrochloric acid; surface adsorption

Research Status

No experimental measurements or instrument records are included in the manuscript. All study-specific numerical values used in this paper are preliminary assumptions and will be replaced with measured ones. They do not represent observations from a finished experiment. The sources cited are valid publications and institutional documents confirmed through scholarly and official channels.

Introduction

Metal corrosion involves chemical reactions between the substrate and its environment and is associated with metal loss and a change in the state of the metal surface. In acidic environments, the metal corrosion can be reduced via modifications in reactions occurring at the metal/solution interface. The efficiency of the inhibitors depends on the metal, electrolyte, concentration, temperature, and time of exposure.

Glycine and alanine constitute the right candidates for exploring these dependencies due to their different structures. Specifically, alanine has a methyl side chain instead of glycine's hydrogen. Both molecules have an amino and a carboxyl group and can be used to investigate the effect of a minor structural difference on the inhibition efficiency.

However, the inhibition properties depend on the structure and charge of the molecule, on the competition between water and electrolyte molecules, and on the inhibition itself. Thus, a molecule may effectively inhibit the corrosion of one metal under certain conditions and fail to do so in different settings.

Accordingly, this paper describes a particular experimental system – mild steel corrosion in hydrochloric acid. Though the title speaks about metal surfaces in general, the expected results do not guarantee the efficiency for copper, aluminum, stainless steel, and other metals without dedicated tests.

The main goal of this paper is to compare glycine and alanine at the same concentration. The additional goals concern the temperature dependence, consistency between measurement techniques, proof of surface adsorption, and limitations of environmental safety claims.

Literature Review

Direct Evidence Concerning Glycine and Alanine

Ashassi-Sorkhabi, Majidi, and Seyyedi (2004) studied the effect of alanine, glycine, and leucine on steel corrosion in hydrochloric acid. The authors demonstrated that the efficiency of inhibition depends on the compound and concentration of the acid. Thus, their paper demonstrates relevance to the current comparison while confirming the necessity of specifying the experimental conditions.

Eddy et al. (2011) performed a combined experimental and computational study of cysteine, glycine, leucine, and alanine. It provides a basis for the simultaneous investigation of concentration, temperature, and molecular properties. Nevertheless, the correlation between the computational properties and efficiency of inhibition does not determine the composition of the adsorbed layer independently.

Amin et al. (2010) explored the inhibition of the iron corrosion by alanine, cysteine, and S-methyl cysteine in

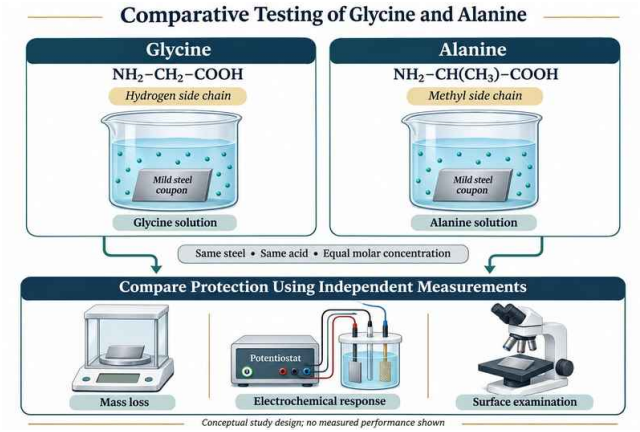
hydrochloric acid. According to the results, alanine acted predominantly as a cathodic inhibitor, while the sulfur-containing molecules had the mixed-type of behavior. The conclusion warns about the necessity of considering different mechanisms of inhibition for various amino acids.

Amin, Khaled, and Fadl-Allah (2010) studied glycine and its derivative on cold-rolled steel using several corrosion monitoring methods. The paper emphasizes the importance of comparing electrochemical estimation and independent measurements of corrosion rate.

Substrate Dependence and Adsorption Interpretation

Amin and Khaled (2010) investigated the effect of glycine, alanine, valine, and tyrosine on the copper corrosion in the oxygen-saturated sulfuric acid. It proves that the amino-acid inhibition extends beyond steel, but the substrate, the cathodic reaction, and the electrolyte are different from the current experiment; thus, the results do not allow predicting the expected steel ranking.

El Ibrahimi et al. (2020) provided a review of amino acids and their derivatives for metals and alloys. It demonstrates considerable dependence on the molecular structure and environmental conditions including those in which the acids promote the corrosion. Therefore, the review supports the necessity of defining the application conditions before claiming a general effect.



Kokalj (2023) studied the interpretation of Langmuir and other adsorption isotherms in corrosion research. His paper draws attention to the issues connected with fitting and contradictory with the assumptions of the models. The strong linear correlation does not prove monolayer adsorption or validity of the adsorption free energy calculation.

Testing Quality and Environmental Claims

ASTM G31 provides the basic criteria for the laboratory immersion tests concerning specimen preparation, solution composition, time of exposure, cleaning, and the rate of corrosion calculation. It allows making consistent gravimetric comparisons. The proposed protocol does not claim the compliance with all standards unless the applicability of every single requirement is confirmed.

Marzorati, Verotta, and Trasatti (2019) provided a review of natural-source corrosion inhibitors and stressed the importance of more rigorous characterization and evaluation. It confirms that renewable sourcing does not guarantee the environmental safety.

Verma et al. (2024) explored the relation between corrosion protection and green-chemistry principles. It allows going beyond the inhibition efficiency towards the evaluation of the synthesis, dose, resource consumption, and environmental impact.

OECD Test Guideline 301 provides well-known methods for ready-biodegradability tests. Corrosion measurements cannot replace them and the biological role of amino acids cannot prove the behavior of the industrial discharge with dissolved metals.

Research Gap and Objectives

The existing literature provides the proof of relevance to both amino acids but employs different substrates, electrolytes, concentrations, and techniques. The main goal of this paper is to perform the comparison based on equal molar concentrations of the substances with the use of independent specimens and appropriate interpretation.

The study aims to check the reproducibility of alanine's advantage over glycine, the persistency of the effect with temperature increase, and consistency between the electrochemical protection and integrated corrosion rate.

Materials and Methods

Research Design

The planned investigation deals with glycine and L-alanine in aerated and unstirred 1.0 mol/L hydrochloric acid. The initial concentration series comprises 1, 2, 5, and 10 mmol/L at 298 K.

The temperature sensitivity will be checked at 10 mmol/L and at 308 and 318 K with the corresponding blanks. This will provide fifteen different formulations and temperatures.

For every condition and method five independent specimens are proposed. Gravimetry, impedance, and polarization will be carried out with separate specimens to prevent interference between measurement techniques.

Table 1. Proposed Experimental Structure

Component	Specification
Substrate	Mild steel from one documented batch
Electrolyte	1.0 mol/L HCl
Compounds	Glycine and L-alanine

Component	Specification
Concentrations at 298 K	1, 2, 5, 10 mmol/L
Additional temperatures	308 and 318 K at 10 mmol/L
Gravimetric exposure	6 hours
Independent specimens per condition and method	5
Unique conditions	15
Specimens per measurement family	75

These numbers define the protocol of the experiment; they do not reflect the work done.

Materials and Specimen Preparation

Steel composition is determined from the chosen batch and is reported in the paper. Specimens are prepared by polishing through certain sequence of abrasives and cleaning, drying, and weighing.

Gravimetric specimens have the total exposed surface of 10 cm^2 and are immersed in 250 mL of solution. Electrochemical specimens have the exposed surface of 1 cm^2 within a certain cell volume.

All preparations are performed using the same procedure and duration, edge treatment, and storage period. Specimen test sequence is randomized, and blanks are included into preparation batches to track possible daily drifts.

Purity and stereochemical structure of the inhibitors are defined. Equal molar concentrations are used to provide the identical exposure to molecules, otherwise equal mass concentrations would mean different number of molecules.

Solution Preparation

Stock solutions are prepared gravimetrically and then diluted by volumetric means. The concentration of the hydrochloric acid remains constant upon addition of the inhibitors.

At 10 mmol/L the loadings of inhibitors are 0.751 g/L for glycine and 0.891 g/L for alanine. The numbers are based on solution preparation and not on inhibition measurements.

Temperature is kept within certain tolerance and is continuously measured. Solutions are not stirred mechanically; thus, the results refer to the described static conditions.

Gravimetric Measurements

Specimens are exposed for six hours, washed using an appropriate procedure, dried, and weighed. Wash controls track the substrate loss due to washing process itself.

Corrosion rate is calculated as:

$$CR = \Delta m / (A\ t)$$

where Δm is the corrected mass loss, A is the exposed surface, and t is the exposure time.

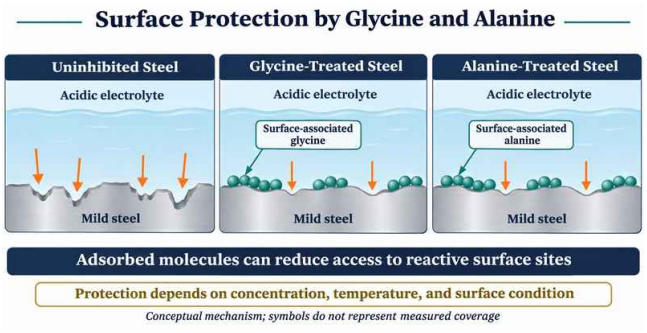
The inhibition efficiency is:

$$IE_WL = (1 - CR_i / CR_0) \times 100$$

The absolute corrosion rates are provided alongside with the percentages to indicate the residual substrate loss.

Electrochemical Measurements

Three-electrode set-up is used; it includes mild steel as the working electrode, an appropriate reference electrode, and an inert counter electrode. Reference electrode identity, geometry, and potential scale are reported.



Open circuit potential is stabilized for at least half an hour until the pre-defined drift criterion is reached. The impedance is measured around the open circuit potential.

The equivalent circuit is chosen according to the response. The fitted parameters are accompanied by uncertainty estimates and residual diagnostics; constant phase element is not automatically identified as a capacitor.

Polarization measurements are performed on fresh specimens. Fitting region for the estimation of corrosion current density is reasonable and no extrapolation through obviously inappropriate data is used.

Surface Examination

Unexposed, exposed without inhibitor, and inhibited specimens are examined by scanning electron microscopy at certain points under the same conditions.

Surface spectroscopy may be used to investigate inhibitor-associated species; nitrogen detection alone does not provide information about orientation of the molecules and surface coverage. Appropriate controls should be made for contamination and dried solution.

No assumption about the surface morphology and spectrum is made before measurement.

Statistical and Adsorption Analysis

The finished study will report specimen-level data including means, standard deviation, and confidence intervals. Temperature Sensitivity

Experimental framework and data interpretation

- Compound, concentration, and temperature effects are analyzed with an appropriate model with consideration of preparation batch where appropriate.
- Inhibition-derived apparent coverage is separated from direct measurement of molecular coverage. Adsorption models are used when underlying assumptions and concentration range are justified.
- No statistical significance, adsorption constant, activation energy, or adsorption free energy is claimed without corresponding observational data.

Results

Concentration-Dependent Inhibition

Table 2 contains the provisional polarization-based values.

Concentration, mmol/L	Glycine	Alanine
1	30.0%	34.0%
2	45.0%	50.0%
5	60.0%	65.0%
10	68.0%	72.0%

According to the stated assumptions, both compounds increase protection with concentration growth with decreasing additional effect at higher concentrations.

At 10 mmol/L alanine exceeds glycine in 4 percentage points. This relatively small value needs uncertainty estimation before any claims about superiority.

Electrochemical Parameters

Table 3. Provisional Electrochemical Data at 10 mmol/L and 298 K

Condition	Corrosion current density, μA/cm²	Charge-transfer resistance, Ω·cm²	Polarization efficiency	Impedance efficiency
Blank	800	25.0	—	—
Glycine	256	75.0	68.0%	66.7%
Alanine	224	86.2	72.0%	71.0%

Polarization efficiency is defined by the decrease in corrosion current. Impedance efficiency is calculated as:

$$IE_EIS = (1 - R_ct,0 / R_ct,i) \times 100$$

Both approaches give similar but not equal provisional values. Their consistency is descriptive and cannot prove the validity of either approach without experimental quality control.

Gravimetric Data

Table 4. Provisional Mass-Loss Data at 298 K

Condition	Corrosion rate, mg/(cm²·h)	Coupon mass loss, mg	Gravimetric efficiency
Blank	0.80	48.0	—
Glycine, 10 mmol/L	0.27	16.2	66.3%
Alanine, 10 mmol/L	0.24	14.4	70.0%

Mass losses correspond to the surface of 10 cm² during 6 hours of exposure.

Alanine decreases the corrosion rate by 70.0%; in contrast to glycine the latter shows 66.25% inhibition efficiency. Thus, the rate of alanine is 11.11% lower than the inhibited rate of glycine; this example demonstrates why percentage point differences and relative rate differences should not be equated. Provisional Polarization Data at 10 mmol/L**

Temperature	Blank current, μA/cm²	Glycine current, μA/cm²	Glycine efficiency	Alanine current, μA/cm²	Alanine efficiency
298 K	800	256	68.0%	224	72.0%
308 K	1,200	456	62.0%	408	66.0%
318 K	1,800	828	54.0%	738	59.0%

Both the corrosion current and residual corrosion increase with temperature. Glycine efficiency drops by 14 percentage points, while alanine efficiency declines by 13.

These assumptions do not prove any desorption or adsorption mechanism. Temperature change can influence several interfacial processes simultaneously.

Comparison Between Methods

At 298 K and 10 mmol/L all three methods indicate slight superior protection of alanine. However, the provisional differences are too small to influence interpretation.

Neither the standard deviations, confidence intervals, nor probabilities are provided since there are no replicate measurements. In addition, there is no report of microscopy findings as results.

Discussion

Influence of the Methyl Side Chain

The presence of the methyl side chain of alanine presents a possible explanation of differences in the interfacial properties relative to glycine. This group may influence the molecular organization, solvent interaction, and arrangement of adsorbed layer.

Nevertheless, the methyl group also affects molecular size and steric properties of the molecule. The results do not determine which effect is more important. Structural explanation requires supporting surface evidence and adequate modeling.

Thus, the difference should be stated as a hypothesis to test, rather than being claimed as the proof of increased inhibition efficiency in case of larger aliphatic substitution.

Protection Versus Adsorption

Reduction in corrosion current indicates a changed electrochemical behavior of the specimen; it does not prove the number of adsorbed molecules by itself.

Inhibitors may modify the kinetics of local reactions, corrosion products formation, and surface chemistry. Estimation of inhibition efficiency in terms of surface coverage requires the justification of the relation.

Similarly, successful fitting of adsorption equation does not prove the underlying mechanism on its own. Model evaluation should take into account assumptions and uncertainty, as suggested by Kokalj's analysis.

Practical and Environmental Significance

The results show that the inhibition efficiency is insufficient. For instance, even 70% reduction is still far from complete protection.

Therefore, the practical assessment should consider the absolute corrosion rate, effective dose, temperature, flow, and time of exposure. Glycine or alanine can be used in certain period but not necessarily continuously.

Their natural occurrence does not prove the environmental safety of the discharged acid with dissolved metals. Evaluations related to biodegradation, toxicity, and waste treatment are still independent.

Limitations

There were no experiments carried out, and the numerical results obtained are preliminary.

The suggested system involves only one batch of steel together with one acidic electrolyte, which means that the obtained results cannot be generalized for another metal, neutral environment, coating, or flowing system.

The procedure does not imply evaluating film longevity and possible interaction with other treatment chemicals. Considering that there are only five specimens for each condition, the statistical significance might turn out to be inadequate provided that the variability in the pilot test is significant.

Conclusion

The choice of glycine and alanine as the subject for studying amino-acid-based corrosion inhibition is justified since they have similar functional groups but different side chains.

The framework suggested combines the tests of various concentrations and temperatures with gravimetric measurements, electrochemical measurements, and surface characterization. The preliminary numbers indicate a slightly higher protective effect of alanine, yet the variability observed implies the necessity of collecting more data in order to make sure that there is a real difference between the two amino acids.

Making decisions about practical application requires taking into account residual corrosion and the conditions of application, along with environmental evidences.

Further research should involve studying more grades of steel, flow conditions, exposure time, and independent determination of surface adsorption.

Future Research

Further research should involve investigating different grades of steel, controlled flow conditions, longer exposure periods, and the independent evaluation of surface adsorption. Besides performance testing, environmental evaluation and the compatibility with treatment should be considered.

Data Availability

There are no experimental data sets, surface images, and instrument files attached to this manuscript.

Funding and Competing Interests

Funding sources and competing interests should be reported depending on the actual situation of the authors.

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