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Corrosion Inhibition of API 5L X56 Steel in HCl Solution Using Expired Dolutegravir: Evaluation by Weight Loss and SEM–EDX Techniques

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ABSTRACT
Corrosion of pipeline steels in acidic environments remains a major industrial concern, particularly during acid pickling, descaling, and oil well acidizing operations. API 5L X56 steel, extensively used in oil and gas transportation, is highly vulnerable to acid-induced corrosion. This study investigates the corrosion inhibition performance of expired Dolutegravir for API 5L X56 steel in 1.0 M HCl using weight loss and SEM–EDX analyses. The results showed that inhibition efficiency increased with inhibitor concentration, reaching a maximum value of 92.3%, indicating strong adsorption of Dolutegravir molecules onto the steel surface. Adsorption isotherm analysis suggests physisorption mechanism. Surface characterization revealed severe degradation in the uninhibited medium, whereas inhibited samples exhibited a smoother morphology with reduced corrosion damage. EDX analysis confirmed the presence of adsorbed protective species on the steel surface. The findings demonstrated that expired Dolutegravir acts as an efficient, eco-friendly, and cost-effective corrosion inhibitor, highlighting its potential application in sustainable corrosion control and pharmaceutical waste valorization.

Keywords:
API 5L X65,
Dolutegravir, HCl,
Weight Loss,
SEM-EDX,

INTRODUCTION

Corrosion is an electrochemical process that results in the deterioration of metals due to environmental interactions (Kamal *et al.*, 2021). Carbon steels such as API 5L X56 are extensively used in oil and gas pipelines due to their mechanical strength and cost-effectiveness. However, these steels are highly vulnerable to corrosion in acidic media such as hydrochloric acid (HCl), which is commonly used in industrial cleaning and oil well acidizing processes (Vaszilcsin *et al.*, 2023).

Hydrochloric acid accelerates anodic iron dissolution and cathodic hydrogen evolution reactions, leading to significant material degradation. Among corrosion mitigation strategies, the use of organic corrosion inhibitors remains one of the most practical and economical methods (Tanwa & Shukla, 2022). Organic compounds containing heteroatoms such as nitrogen, oxygen, sulfur, and aromatic rings exhibit strong adsorption on metal surfaces due to lone pair electrons and π-bonds (Bentiss *et al.*, 2000). Recently, research has focused on environmentally friendly inhibitors, including plant extracts and pharmaceutical drugs (Verma *et al.*, 2018).

Expired pharmaceutical drugs have attracted increasing attention as potential corrosion inhibitors because they contain complex molecular structures with multiple adsorption centers, and their reuse helps address environmental disposal concerns (Eddy & Ebenso, 2010). Despite the growing body of literature on drug-based inhibitors, limited information is available regarding the corrosion inhibition performance of antiretroviral drugs, particularly Dolutegravir, in acidic environments. Dolutegravir, an antiretroviral drug used in HIV treatment, contains nitrogen, oxygen, fluorine atoms, and aromatic systems (Kandel & Walmsley 2015), capable of forming coordination bonds with metal surfaces.

However, to date, no comprehensive study has systematically evaluated the inhibition efficiency, adsorption behavior, and thermodynamic characteristics of Dolutegravir on API 5L X56 steel in hydrochloric acid solution. The knowledge gap lies in understanding its mechanism of interaction with the steel surface, its effectiveness under varying concentrations and temperatures, and whether its molecular structure translates into practical corrosion protection performance in aggressive acidic media.

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Therefore, the objective of this study is to investigate the corrosion inhibition performance of Dolutegravir on API 5L X56 steel in 1.0 mol dm^{-3} HCl solution using weight loss and surface characterization techniques SEM-EDX. By addressing this knowledge gap, this work seeks to contribute to the development of sustainable, cost-effective corrosion inhibitors derived from expired pharmaceutical compounds

MATERIALS AND METHODS

Materials and Test Solutions

API 5L X65 pipeline steel was used as the test material in this study. The steel was obtained from Kaduna Refining and Petrochemical Company (KRPC), Kaduna State, Nigeria. The material was originally manufactured by Vallourec Brasil and supplied to Daewoo Engineering & Construction Nigeria Ltd for maintenance and repair operations at the refinery.

The chemical composition of the steel (wt%) was: C (0.16), Mn (1.65), P (0.02), S (0.045), Si (0.50), Ni (0.50), Cr (0.05), Mo (0.50), Al (0.06), Cu (0.50), V (0.09), Nb (0.05), B (0.005), Ti (0.06), N (0.12), and Fe (97.04).

The corrosive medium was 1.0 mol dm^{-3} hydrochloric acid (HCl), prepared by appropriate dilution of analytical grade 37% HCl with distilled water. Fresh acid solutions were prepared prior to each experiment.

Expired Dolutegravir tablets (50 mg), manufactured by Aurobindo Pharma, India (expiry date: November 2023) obtain from ARD clinic of Abubakar Tafawa Balewa University Teaching Hospital Bauchi, Nigerian were used as received without further purification. The inhibitor concentrations of 50, 100, 150, 200, and 250 mg L^{-1} were prepared directly in the 1.0 mol dm^{-3} HCl solution.

Dolutegravir, chemically named (3S,7R)-N-[(2,4-difluorophenyl) methyl]-11-hydroxy-7-methyl-9,12-dioxo-4-oxa-1,8-diazatricyclo[8.4.0.$0^{3,8}$]tetradeca-10,13-diene-13-carboxamide, has the molecular formula $C_{20}H_{19}F_2N_3O_5$. Its molecular structure contains multiple heteroatoms (N and O), fluorine substituents, and conjugated π-electron systems, which are favorable for adsorption onto metal surfaces.

All experiments were conducted at temperatures of 303, 313, 323, and 333 K using a thermostatically controlled water bath to maintain constant temperature throughout the immersion period.

Preparation of Steel Coupons

The steel coupons were prepared according to the standard cleaning procedure described in ASTM International ASTM G1 (1999). The steel Pipe was mechanically cut into rectangular specimens with dimensions of 3.0 × 1.0 × 0.1 cm.

Prior to each experiment, the coupon surfaces were sequentially polished using silicon carbide abrasive papers of grades 400, 600, 800, 1000, and 1200 grit to obtain a smooth surface finish. The polished specimens were rinsed thoroughly with distilled water, degreased with ethanol, washed with acetone, air-dried, and stored in a desiccator to prevent moisture adsorption before use.

Preparation of the Inhibited Solution

Dolutegravir was available as a tablet with a drug strength of 50 mg. So to prepare the inhibited solution of a concentration range (50mg/L – 250 mg/L). A total of 1, 2, 3, 4, and 5 tablets was compounded separately and transferred into a different 1000 mL volumetric flasks containing approximately 500 mL of 1.0 mol dm^{-3} HCl solution each. The mixture was shaken vigorously, and then 1.0 mol dm^{-3} HCl solution was added to the mark.

Weight Loss Measurements

Gravimetric (weight loss) measurements were performed according to the immersion test method described in ASTM G31 (2012). Each pre-weighed steel coupon was immersed in 200 mL of 1.0 mol dm^{-3} HCl solution in the absence (blank) and presence of different concentrations of Dolutegravir (50–250 mg L^{-1}).

The immersion period was fixed at 3 hours interval at 303, 313, 323, and 333 ± 1 K. After immersion, the specimens were removed and cleaned to eliminate corrosion products following ASTM G1 (1999) procedures. The cleaning process involved immersion in 20% NaOH solution containing 100 g L^{-1} zinc dust for 2–5 minutes. The specimens were then scrubbed gently under running tap water using a soft bristle brush, rinsed thoroughly, degreased with ethanol, washed with acetone, dried, and reweighed.

All measurements were performed in triplicate to ensure reproducibility, and the average weight loss values were recorded. The corrosion rate (CR), inhibition efficiency (%IE), and surface coverage (θ) were calculated using standard gravimetric equations (Onen *et al.*, 2019):

To determine the weight loss due to corrosion, the initial and final weights of the mild steel specimen are measured. The weight loss (w) is calculated by subtracting the final weight from the initial weight of the specimen. The equation for weight loss is as follows:

$$W_i - W_f = w \quad (1)$$

Where; w is total weight loss, W_i and W_f are the initial weight before immersion and after respectively.

In order to quantify the corrosion rate (CR) of mild steel in the absence and presence of the corrosion inhibitor, we use the formula, which relates the corrosion rate to the total weight loss and period of immersion:

$$\text{Corrosion rate(mmpy)} = \frac{87.6w}{DAT} \quad (2)$$

Where w = Total weight loss (mg), D = density of specimen (g/cm^3), A = Area of specimen (square meter) and T= period of immersion (hour) and 87.6 is a conversion factor. The density of the API 5L X65 is 7.85 g/cm^3.

To determine the effectiveness of the corrosion inhibitor, the surface coverage (θ) is calculated using the ratio of the weight loss of mild steel in the presence and absence of the inhibitor and subtract from one. The surface coverage represents the fraction of the metal surface that is covered by the inhibitor molecules, which prevents the electrochemical reactions responsible for corrosion. The formula for calculating surface coverage is given by:

$$\theta = \left(1 - \frac{w_1}{w_2}\right) \quad (3)$$

Where; w_1 and w_2 are the weight losses (g) for metal in the presence and absence of inhibitor respectively.

The inhibition efficiency (%IE) quantifies the extent to which the corrosion rate is reduced by the presence of an inhibitor. It is calculated by multiplying the value of surface coverage by 100. A higher value of %IE indicates a more effective inhibitor. The formula for inhibition efficiency is given by:

$$\%IE = \left(1 - \frac{w_1}{w_2}\right) \times 100 \quad (4)$$

SEM-EDX Analysis

The surface morphology of the API 5L X65 steel coupons, following immersion in a 1.0 M HCl solution for 3 hours at 303 K in the presence and absence of inhibitors, was analyzed using a Phenom ProX SEM-EDX (Netherlands).

RESULTS AND DISCUSSION

The results obtained from the weight loss measurements, including corrosion rate (CR), surface coverage (θ), and inhibition efficiency (%IE), are presented in Table 1.

Table. 1: Shows the Corrosion parameters of API 5L X 65 mild steel from weight loss measurement.

Inh. (mg/l)	Surface Coverage				Corrosion Rate (mm/yr)				Inhibition efficiency			
	303K	313K	323K	333K	303 K	313 K	323 K	333 K	303 K	313K	323K	333K
Blank	-	-	-	-	0.0105	0.0158	0.0218	0.0343	-	-	-	-
50	0.650	0.564	0.537	0.329	0.0036	0.0068	0.0101	0.0230	65.0	56.4	53.7	32.9
100	0.692	0.615	0.574	0.353	0.0032	0.0061	0.0092	0.0222	69.2	61.5	57.4	35.3
150	0.730	0.641	0.593	0.376	0.0028	0.0056	0.0088	0.0214	73.0	64.1	59.3	37.6
200	0.846	0.692	0.611	0.400	0.0020	0.0048	0.0084	0.0206	84.6	69.2	61.1	40.0
250	0.923	0.718	0.685	0.424	0.0008	0.0044	0.0068	0.0198	92.3	71.8	68.5	42.4

The data clearly indicate that inhibition efficiency increases with increasing inhibitor concentration. This behavior suggests that a greater number of inhibitor molecules are adsorbed onto the mild steel surface at higher concentrations, resulting in enhanced surface coverage and effective blocking of active corrosion sites. Consequently, the dissolution of the metal in the aggressive medium is significantly suppressed.

The improvement in inhibition efficiency with concentration is consistent with adsorption-controlled corrosion inhibition mechanisms reported in the literature (Shwetha *et al.,* 2024). As the inhibitor concentration increases, the availability of adsorption sites on the metal surface becomes progressively occupied by inhibitor molecules, leading to the formation of a protective barrier film. High inhibition efficiency values therefore correspond to a substantial reduction in corrosion rate, confirming the protective capability of the inhibitor system (Shwetha *et al.,* 2024; Karthik & Sundaravadivelu 2015).

At the optimum inhibitor concentration investigated, the highest inhibition efficiency recorded was **92.3%,** demonstrating excellent corrosion protection performance. This high efficiency indicates strong interaction between the inhibitor molecules and the steel surface, leading to the formation of a compact and adherent protective film that effectively isolates the metal from the corrosive environment.

Overall, the weight loss results confirm that the inhibitor exhibits concentration-dependent performance and good adsorption characteristics, with maximum protection achieved at the optimum concentration.

Temperature Dependence and Thermodynamic Parameters

The effect of temperature on the inhibition process revealed that an increase in temperature results in a decrease in inhibition efficiency. This inverse relationship is typically attributed to several factors: (i) acceleration of the metal dissolution process due to increased kinetic energy of the reacting species, (ii) an increase in desorption rate of inhibitor molecules from the metal surface, and (iii) the alteration of adsorption mechanisms due to unfavorable thermodynamic conditions at higher temperatures (Ikeuba *et al.,* 2025). The reduced inhibition efficiency at elevated temperatures indicates that the adsorption of the inhibitor may involve predominantly physical adsorption**,** which is less stable at higher temperatures compared to chemical adsorption (Obot & Obi-Egbedi.2010; Ojochide *et al.,* 2015).

Thermodynamic parameters such as activation energy (E_a)**,** adsorption free energy ($\Delta G°_{ads}$)**,** enthalpy ($\Delta H°$)**,** and

entropy (ΔS°) play a crucial role in understanding the interaction between the inhibitor molecules and the metal surface. These parameters can be derived from the temperature dependence of the corrosion rate and inhibition efficiency.

Adsorption Isotherms

Two widely used adsorption models, the **Langmuir** and **Temkin** isotherms, were applied to analyze the adsorption behavior of the Dolutegravir onto the steel surface. Result indicated that it obey Langmuir isotherm. Langmuir adsorption isotherm described by the following equation;

$$\log\frac{C}{\theta} = -\log K_{ads} + \log C \quad (5)$$

A plot of $\log\frac{C}{\theta}$ verse log C from equation 9, a straight line was obtain with an intercept equal $-\log K_{ads}$ as shows in Fig 1.

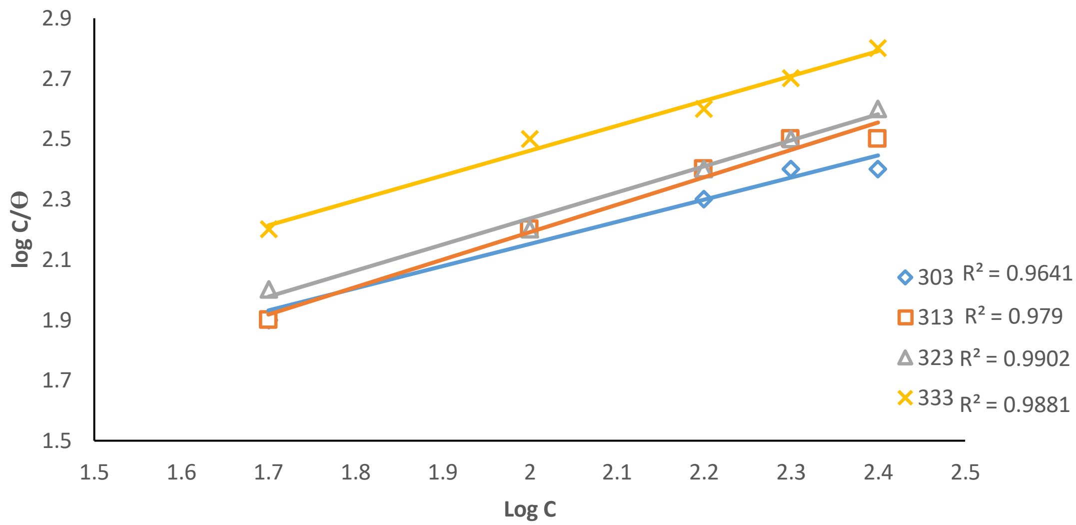


Fig. 1: Langmuir adsorption isotherm for the API 5L X65 mild inhibited in the presence of Dolutegravir.

Adsorption Free Energy (ΔG°$_{ads}$)

The adsorption free energy **(ΔG°$_{ads}$)** is an important thermodynamic parameter that provides information about the spontaneity of the adsorption process and is related with equilibrium constant of adsorption K_{ads} in the following equation:

$$\Delta G^{o}_{ads} = -2.303RT\log(55.5K_{ads}) \quad (6)$$

Where ΔG^{o}_{ads}= Gibbs free energy, R= Molar gas constant, T= absolute temperature and K_{ads} = the equilibrium constant for adsorption.

The values of ΔG^{o}_{ads} calculated were listed together with the adsorption parameters evaluated from Fig, 3 in Table 2 below.

Table. 2: Isotherm parameters for the Adsorption of inhibitor on to the surface of API 5l X65 steel in 1.0 M HCl at various Temperatures.

Adsorption Isotherm	Inhibitor	Temp (K)	Slope	Intercept	K_{ads}	ΔG_{ads} (kJmol^{-1})	R^2
Langmuir	Dolutegravir	303	0.7338	0.6844	4.84	-14.09	0.9641
		313	0.9091	0.3927	2.36	-12.69	0.9790
		323	0.8736	0.5011	3.23	-13.94	0.9902
		333	0.8247	0.8117	5.48	-16.30	0.9881

A negative value of ΔG^{o}_{ads} suggests that the adsorption of the inhibitor on the metal surface is spontaneous, while a highly negative ΔG^{o}_{ads} implies a strong interaction between the inhibitor and the metal surface. A value of ΔG^{o}_{ads} more negative than -40 kJ/mol typically indicates physisorption**,** whereas values more negative than **-80 kJ/mol** are associated with **chemisorption** (Toghan *et al.*, 2023).

The calculated value of ΔG^{o}_{ads} turns out to be negative indicating that the adsorption of Dolutegravir is spontaneous and proceed via physical adsorption with the value which range between (-12 to -17 kJmol^{-1}) which were less the physisorption threshold value of -40 kJmol^{-1}

Activation Energy (E$_a$)

The activation energy **(E$_a$)** provides insight into the energy required to initiate the corrosion process. A higher activation energy typically suggests that the corrosion process is more difficult to initiate, which indicates stronger inhibition (Quraishi *et al.*, 2012). The activation energy can be calculated using the Arrhenius equation:

$$\log CR = -\frac{E_a}{2.303RT} + \log A \qquad (7)$$

Where CR is corrosion rate, R the molar gas constant (8.314 J/mol/K), T is the absolute temperature and A is the Arrhenius constant respectively.

Plotting natural logarithm of the corrosion rate (log CR) verse 1/T in absence and presence of the inhibitor at various concentrations the E_a values were evaluated from their slope and listed in Table 2, with other thermodynamic parameters (Fig. 2).

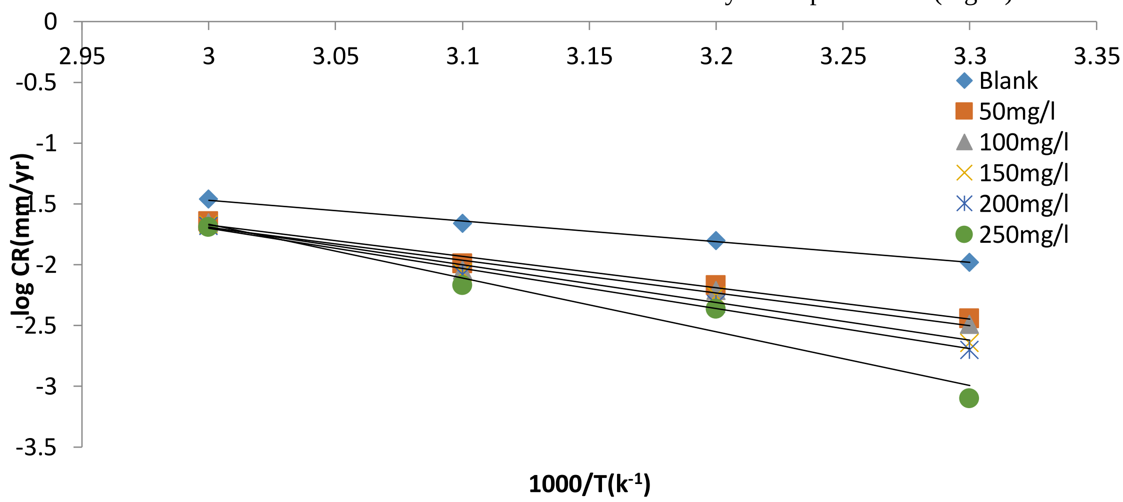


Fig. 2: Arrhenius plot for the inhibition of API 5L X65 steel Dolutegravir as inhibitor.

Enthalpy (ΔH*) and Entropy (ΔS*)

The **Van't Hoff equation** is used to relate the temperature dependence of the rate constant (or corrosion rate). By examining the temperature dependence, we can extract the activation parameters such as the enthalpy and entropy of activation. The equation is given by;

$$\log \frac{CR}{T} = \left[\log\left(\frac{R}{Nh}\right) + \frac{\Delta S^*}{2.303R}\right] - \frac{\Delta H^*}{2.303RT} \qquad (8)$$

Where h is the plank's constant and N is the Avogadro's number, respectively.

A plot of $\log \frac{CR}{T}$ verse $\frac{1}{T}$ gave a straight line with a slope of $\frac{-\Delta H^*}{2.303R}$ and intercept of $[\log\left(\frac{R}{Nh}\right) + \frac{\Delta S^*}{2.303R}]$, from which the activation thermodynamics parameters (ΔH^*) and (ΔS^*) were evaluated from Fig. 3, and summarize in Table 3.

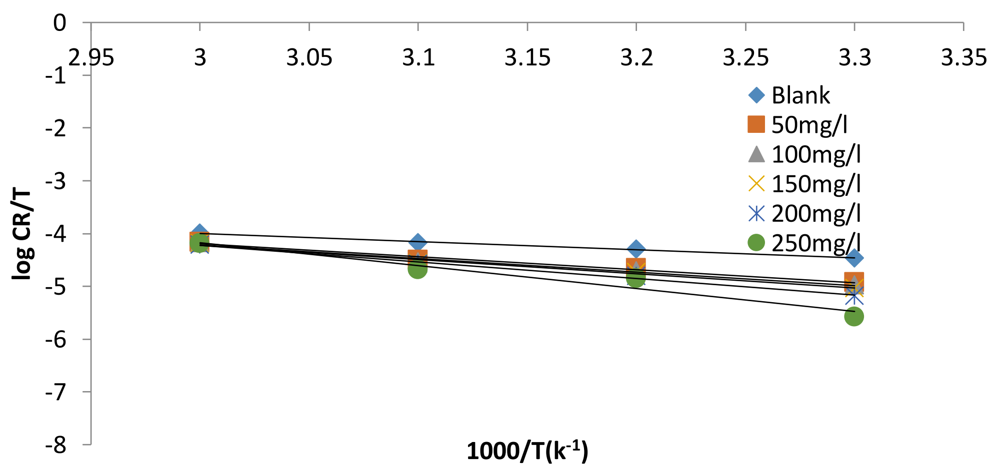


Fig. 3: Transition state plot for the inhibition of API 5L X65 steel Dolutegravir as inhibitor

Table. 3: Thermodynamic parameters for corrosion inhibition of API 5L X65 mild steel in absence and present of an inhibitor.

Inhibitor Conc.(mg/L)	Ea (kJ/mol)	**−ΔH*** (kJ/mol)	**−ΔS*(kJ /mol)**
Blank	32.56	29.49	209.52
50	49.41	47.30	259.25
100	51.51	49.22	264.52
150	59.37	51.51	271.28
200	63.20	60.13	297.13
250	84.64	83.11	367.03

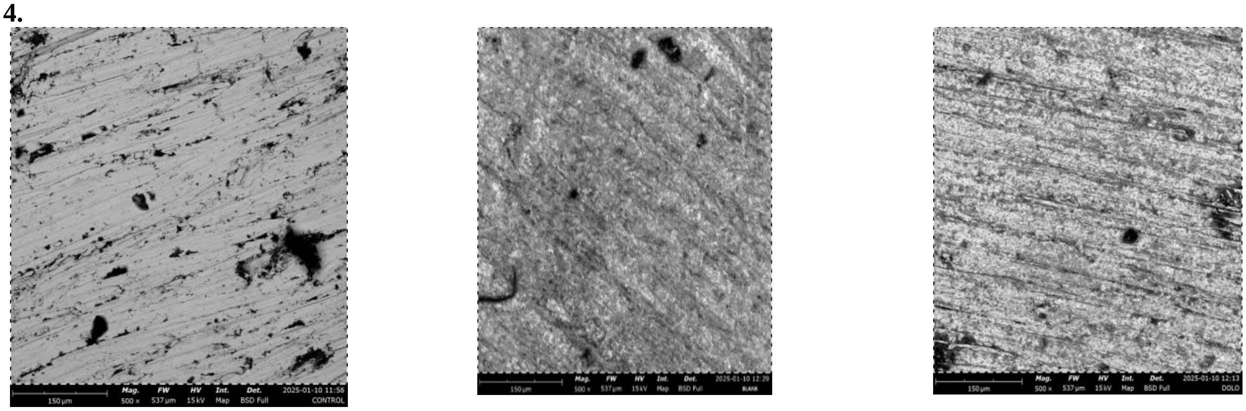
The negative values of **enthalpy (ΔH*)** indicate that the adsorption of the inhibitor onto the steel surface is exothermic, meaning that the process releases heat, and the interaction between the inhibitor molecules and the metal is thermodynamically favorable (Nsude & Orie 2022; Lijesh *et al.,* 2024). A more negative **ΔH*** value suggests a stronger interaction between the inhibitor and the steel surface, which is consistent with stronger chemisorption **or** physisorption mechanisms, depending on the inhibitor type (Obot & Obi-Egbedi.2010). It was observed that as the inhibitor concentration increased, the **ΔH*** value became more negative, suggesting that a higher concentration of inhibitor molecules adsorbed onto the steel surface. This leads to the formation of a stronger protective film on the surface, effectively shielding the steel from the corrosive medium (Alamry *et al.,* 2023).

The **entropy (ΔS*)** of adsorption is another important thermodynamic parameter in corrosion studies, as it complements the information provided by **enthalpy**. ΔS* influences the surface coverage and the molecular arrangement of the inhibitor on the metal surface. Positive values of **ΔS** indicate a more disordered arrangement of inhibitor molecules, which can reduce surface coverage and, consequently, lower the inhibition efficiency (Ansari *et al.,* 2022). On the other hand, negative ΔS* values suggest that the formation of activated complexes during the adsorption process involves an association step rather than dissociation, indicating a decrease in disorder as the inhibitor molecules organize on the metal surface (Quraishi *et al.,* 2012). This behavior is commonly observed when the inhibitor molecules adopt a more ordered structure upon adsorption, which strengthens the protective film and improves corrosion resistance.

The **ΔS** values recorded in Table 3 show a decreasing trend with increasing inhibitor concentration, indicating that more inhibitor molecules were adsorbed onto the steel surface. As the concentration of the inhibitor increased, the molecules became more densely packed, reducing the disorder in the system. This aggregation of inhibitor molecules enhances the surface coverage, leading to increased inhibition efficiency and a significant reduction in corrosion rates. Thus, the thermodynamic data support the idea that higher concentrations of inhibitors form a more stable and ordered protective layer on the steel surface, contributing to better corrosion protection.

SEM and EDX Analysis

The surface morphology of the steel before and after exposure to the corrosive medium, as well as after the application of the inhibitor, was examined using **Scanning Electron Microscopy (SEM) as show in Fig. 4.**



a) SEM image of untreated API 5L X65 polished coupon

b) SEM image in the absence of inhibitor (treated with HCl)

c) SEM image in the presence of inhibitor.

Figure. 4: Surface morphology of API 5L X65 in the absence and presence of inhibitor.

SEM images of the steel surface in its pristine state (a) reveal a smooth, clean surface, typical of untreated metal. However, after exposure to the corrosive medium, the surface becomes significantly pitted (b), indicating active corrosion, with the formation of corrosion products and surface degradation due to the interaction between the metal and the corrosive solution. The pitting and rough surface morphology are indicative of localized corrosion, which leads to the deterioration of the steel surface (Rugmini *et al.,* 2018).

In contrast, the steel surface exposed to the corrosive medium in the presence of the inhibitor shows a **much smoother surface (c),** with minimal signs of corrosion or pitting. This suggests that the inhibitor effectively reduced metal dissolution and protected the surface. The smoothness and uniformity of the surface indicate that the inhibitor forms a protective film, which acts as a barrier, preventing the corrosive agents from interacting with the metal (Singh *et al.,* 2016). The SEM images strongly suggest that the inhibitor has a significant role in mitigating corrosion damage and stabilizing the surface.

EDX Analysis

To further support the SEM findings, Energy Dispersive **X-ray (EDX)** spectroscopy was used to analyze the elemental composition of the steel surface before and after exposure to the corrosive solution and inhibitor. The **EDX spectra** of the untreated steel show (Fig. 5) a high intensity of iron (Fe) peaks, indicating that the surface is predominantly composed of the steel substrate. After exposure to the corrosive medium, the EDX spectrum shows (Fig. 6) additional peaks for **oxygen (O)** and **chlorine (Cl)**, confirming the formation of corrosion products such as **iron oxides** and **chloride salts**, which are commonly formed in acidic environments (Peme *et al.,* 2015).

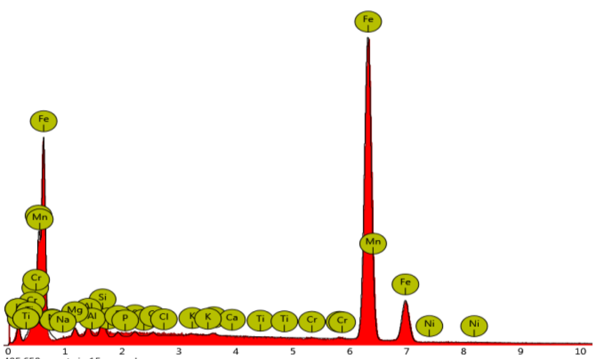


Figure. 5: EDX spectrum of untreated (Blank) API 5L X65 steel

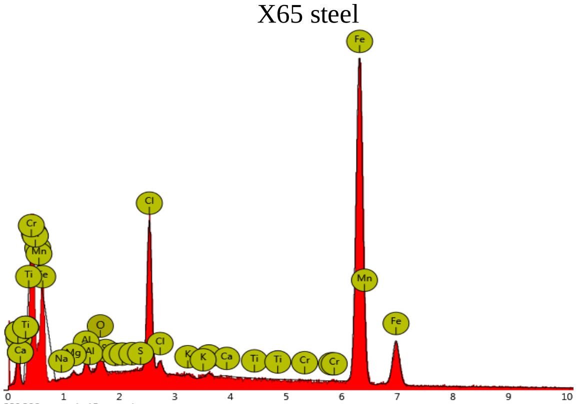


Figure. 6: EDX spectrum of treated API 5L X65 steel in the presence acid.

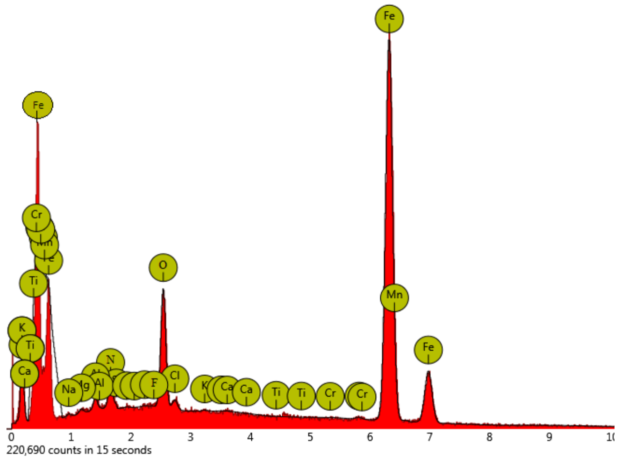


Figure. 7: EDX spectrum of treated API 5L X65 steel in the presence of Dolutegravir drug.

Upon exposure to the inhibitor, the EDX spectra (Fig. 7) reveal a decrease in the intensity of the **chlorine (Cl)** peak and the appearance of nitrogen (N), fluorine (F), and oxygen (O) peaks. The appearance of these peaks (N, F & O) confirms the adsorption of the drug molecule and the formation of a protective film on the steel surface, as these elements are also identified in the chemical structure of the respective drug.

CONCLUSION

The study reveals that Dolutegravir demonstrated high corrosion inhibition performance for mild steel in 1.0 mol dm^{-3} HCl, achieving a maximum efficiency of 92.3%. Gravimetric and SEM-EDX analyses confirmed that the inhibitor significantly reduced corrosion rates through the formation of a uniform and protective surface film. Thermodynamic parameters indicated that the adsorption process is spontaneous (negative ΔG°_{ads}), exothermic (negative ΔH^*), and associated with decreased interfacial disorder (negative ΔS^*), consistent with the formation of a stable and compact adsorbed layer. The adsorption behavior followed the Langmuir isotherm model, suggesting monolayer adsorption without significant lateral interaction between adsorbed species. Overall, the findings highlight Dolutegravir as a promising and environmentally benign corrosion inhibitor for acidic media, with potential applicability in broader industrial environments.

REFERENCE

Alamry, K. A., Khan, A., Aslam, J., Hussein, M. A., & Aslam, R. (2023). Corrosion inhibition of mild steel in hydrochloric acid solution by the expired ampicillin drug. *Scientific Reports, 13,* 6724. https://doi.org/10.1038/s41598-023-33519-y

Ansari, K. R., Quraishi, M. A., Prashant, & Ebenso, E. E. (2013). Electrochemical and thermodynamic investigation of diclofenac sodium drug as a potential corrosion inhibitor for mild steel in hydrochloric acid. *International Journal of Electrochemical Science, 8*, 12860–12873. https://doi.org/10.1016/S1452-3981(23)13312-8

ASTM International. (1999). *ASTM G1: Standard practice for preparing, cleaning, and evaluating corrosion test specimens.* ASTM International.
ASTM International. (2012). *ASTM G31-12a: Standard practice for laboratory immersion corrosion testing of metals.* ASTM International.

Bentiss, F., Traisnel, M., & Lagrenée, M. (2000). The substituted 1,3,4-oxadiazoles: A new class of corrosion inhibitors of mild steel in acidic media. *Corrosion Science, 42*(1), 127–146. https://doi.org/10.1016/S0010-938X(99)00049-9

Ikeuba, I. A., Aondoakan, L., Azagare, W., Njoku, C. N., Usibe, B. E., & Eche, O. (2025). Computational and experimental evaluation of the corrosion inhibition of magnesium in the presence of acids/esters in saline solutions. *Current Research in Green and Sustainable Chemistry*, *10*, 1–12. https://doi.org/10.1016/j.crgsc.2025.100452

Kamal, M., M. Mohse, Q., Anwar, Z., M. & Sherif, M., A. (2021). An expired ceftazidime antibiotic as an inhibitor for disintegration of copper metal in pickling HCl media. *Journal of Materials Research and Technology*, 11. 875 -886. https://doi.org/10.1016/j.jmrt.2021.01.055

Kandel, C. E., & Walmsley, S., L. (2015). Dolutegravir: a review of the Pharmacology, Efficacy and Safety in the treatment of HIV. *Dove Press Journal.* 9, 3547-3555. doi: 10.2147/DDDT.S84850

Karthik, G., & Sundaravadivelu, M. (2015). Studies on the inhibition of mild steel corrosion in hydrochloric acid solution by atenolol drug. *Egyptian Journal of Petroleum, 25*, 183–191. https://doi.org/10.1016/j.ejpe.2015.04.003
Lijesh, K. P., Mahmoudi, A., & Khonsari, M. M. (2024). Experimentally verified thermodynamic framework for corrosion. *Corrosion Science, 233*, 112063. https://doi.org/10.1016/j.corsci.2024.112063

Nsude, O. P., & Orie, K. J. (2022). Thermodynamic and adsorption analysis of corrosion inhibition of mild steel in 0.5 M HCl medium via ethanol extracts of *Phyllanthus mellerianus*. *American Journal of Applied Chemistry, 10*(3), 67–75. https://doi.org/10.11648/j.ajac.20221003.12

Obot, I. B., & Obi-Egbedi, N. O. (2010). Adsorption properties and inhibition of mild steel corrosion in sulphuric acid solution by ketoconazole: Experimental and theoretical investigation. *Corrosion Science, 52*(1), 198–204. https://doi.org/10.1016/j.corsci.2009.09.002

Ojochide, M. O., Habibat, C. F. & Ahulle, W. R. (2025). Anti-corrosion Properties of *Piliostigma Thonningi* Leave Extract-Transition Metal Nano Particle Composites on Mild Steel in 1.0 M Hydrochloric Acid Solution. *Journal of Basics & Applied Sciences Research*, 1(1), 97-109. https://doi.org/10.4314/jobasr.v1i1.10s

Peme, T., Olasunkanmi, L. O., Bahadur, I., Adekunle, A. S., Kabanda, M. M., & Ebenso, E. E. (2015). Adsorption and corrosion inhibition studies of some selected dyes as corrosion inhibitors for mild steel in acidic medium: Gravimetric, electrochemical, quantum chemical studies and synergistic effect with iodide ions. *Molecules, 20*, 16004–16029. https://doi.org/10.3390/molecules200916004

Quraishi, M. A., Ansari, K. R., Yadav, D. K., & Ebenso, E. E. (2012). Corrosion inhibition and adsorption studies of some barbiturates on mild steel/acid interface. *International Journal of Electrochemical Science, 7*, 12301–12315. https://doi.org/10.1016/S1452-3981(23)16546-1

Rugmini, P., Ammal, M. P., & Joseph, A. (2018). Physicochemical studies on the inhibitive properties of a 1,2,4-triazole Schiff's base, HMATD, on the corrosion of mild steel in hydrochloric acid. *Egyptian Journal of Petroleum*, *27*, 307–317. https://doi.org/10.1016/j.ejpe.2017.05.002

Shwetha, K. M., Praveen, B. M., & Devendra, B. K. (2024). A review on corrosion inhibitors types, mechanism, electrochemical analysis, corrosion rate and inhibition efficiency of corrosion inhibitors on mild steel in an acidic environment. *Results in Surfaces and Interfaces*, *16*, 100258. https://doi.org/10.1016/j.rsurfi.2024.100258

Singh, P., Ebenso, E. E., Olasunkanmi, L. O., Obot, I. B., & Quraishi, M. A. (2016). Electrochemical, theoretical, and surface morphological studies of corrosion inhibition effect of green naphthyridine derivatives on mild steel in hydrochloric acid. *Journal of Physical Chemistry C, 120*, 3408–3419. https://doi.org/10.1021/acs.jpcc.5b11901

Tanwer, S., & Shukla, S., K. (2022). Recent advances in the applicability of drugs as corrosion inhibitor on metal surface: A review. *Current Research in Green and Sustainable Chemistry*.**5;** 100227. https://doi.org/10.1016/j.crgsc.2021.100227

Toghan, A., Gadow, H. S., Fawzy, A., Hanan, A., & Salah, H. (2023). Adsorption mechanism, kinetics, thermodynamics, and anticorrosion performance of a new thiophene derivative for C-steel in 1.0 M HCl: Experimental and computational approaches. *Metals, 13*, 1565. https://doi.org/10.3390/met13091565

Vaszilcsin, N., Kellenberger, A., Dan, A. L., Duca, D. A., & Ordodi, V. L. (2023). Efficiency of Expired Drugs Used as Corrosion Inhibitors: A Review. *Materials, 16* (16), 5555. 1-24. https://doi.org/10.3390/ma16165555

Verma, C., Ebenso, E. E., Bahadur, I., & Quraishi, M. A. (2018). An overview on plant extracts as environmentally sustainable and green corrosion inhibitors for metals and alloys in aggressive corrosive media. *Journal of Molecular Liquids, 266*, 577–590. https://doi.org/10.1016/j.molliq.2018.06.110