



Evaluation of Corrosion Inhibition Properties of Pharmaceutically Active Compound Cefotaxime Sodium on Mild Steel Surface in Sulfuric Acid Medium

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Abstract: Cefotaxime sodium is applied in various concentrations in 0.55 yds sulfuric acid for the mild steel and analyzed through weight loss, potentiodynamic polarization, and electrochemical impedance spectroscopy studies from 298 to 338 K. It gives better inhibition activity at lower temperature. Activation parameters, Gibbs free energy, enthalpy, and entropy of the reaction have been calculated. It was found that the inhibition process follows physical adsorption and the adsorption process follows Langmuir's adsorption isotherm. The inhibition behavior is supplemented by the surface study through atomic force microscopy and found that the inhibited surface has less roughness than the uninhibited surface.

Keywords: Eco-friendly inhibitors, weight loss, EIS, AFM.

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INTRODUCTION

Corrosion is the natural phenomenon of the decadence of a material and its properties due to the synergy between the material and its active environment (1). The tendency of metal for corrosion to occur depends upon the surface structure and grain size, its chemical constituent, and the temperature of corrosive environment. Practically, the process of corrosion can be prevented rather than to eliminate completely. Corrosion plays a crucial role in environment, the mechanisms of corrosion is dependent upon the corrosive environment in which material surface is exposed. Corrosion depends upon these factors like metallic reactivity, presence of impurities in the metal, and corrosive medium, the presence of air, moisture, different corrosive gases like sulfur dioxide and carbon dioxide, and the presence of electrolytes (2). Corrosion is a critical and major industrial problem as it causes deterioration of metals and alloys in the presence of a corrosive environment generated by chemical or

electrochemical pathways. Corrosion is an associate degree irrecoverable reaction of a metal, ceramic, or chemical compound with its surroundings which ends up in its consumption or dissolution into the fabric of a part of the surroundings (3–6). It causes significant loss to the total GDP of the nation. Corrosion costs more than 2.0 lakh crores of the Indian economy per year (7–9). Corrosion costs glaring in the form untimely decadence or necessary maintenance failures, repairs, and replacement of damaged parts. Corrosion inhibition can be employed by using chemicals, however almost all chemicals/substances start corrosion in the presence of air, water and soil (10,11).

A chemical which, when added to a corrosive environment and hence reduces the rate of reaction of metal with its corrosive environment, is referred to as a corrosion inhibitor. Corrosive control of metals is aesthetically, economically, environmentally, and technically important (12). The inhibitor used is the best option to protect metals and alloys but there are some major

limitations of organic inhibitors which have leads to the development of green and sustainable inhibitor materials towards control the metal corrosion as they are less toxic, biodegradable, cost-effective, and ecologically acceptable. To replace these toxic and hazardous inhibitors with less toxic and less hazardous inhibitors, many research groups work on developing an environmentally benign sustainable non-toxic corrosion inhibitor likely to have oxygen, nitrogen, and sulfur-like heteroatoms. Numerous natural products and their applications as a corrosion inhibitor, especially in steel, are discussed. Green inhibitors (13) are a need of the time. Research on corrosion has been an interesting topic for quite a long time. Green inhibitors are an old dream in applied corrosion in industrial practice, but one of the challenges is to guarantee or to trust in the chemical stability of the compound. Most of the research groups infer that the inhibitor concentration required is on the higher side but it has its own disadvantages: The higher concentration cannot be guaranteed in real applications over a longer period of time. High concentrations of inexperienced (organic) corrosion inhibitors (14–16) may scale back the barrier properties of a coating and should be not even compatible with the organic coating etc.

In the last few decades, the drugs make their efficient role as a corrosion inhibitor which fascinates research attention. Literature review disclose that various types of drugs (antibacterial, antifungal, antibiotic, anti-malarial, analgesic, anti-depressant, anti-hypertensive, antihistamine) have been efficaciously vibrant as feasible corrosion inhibitors for decreasing effect of corrosion on mild steel and other metals and metal alloys (17–20). The imminent sections deliver comprehensive overview of the application of drugs and the literature on their corrosion inhibition studies. Most widely used metal in industry is mild steel in structural requirements. Acids are used in industrial applications for the purpose of pickling and descaling, etc. To minimize the corrosion due to these activities, corrosion inhibitors play a significant role to protect the metallic surfaces. Among various types of corrosion inhibitors, organic compounds are the most successful and profitable corrosion inhibitors for the protection of metallic surfaces (21). The inhibiting molecule may be adsorbed on the metallic surface due to physical or chemical interactions or it may be the combination of both. Generally organic and inorganic molecules act as corrosion inhibitors in practice are toxic in nature. Therefore, importance of the development of eco-friendly non-toxic corrosion inhibitors is the need of the day. In the current research, the development of corrosion inhibitors from commercially available drugs are used as corrosion inhibitors on metal surface owing to its low LD50 values (19, 22–28) in acidic media.

Cefotaxime sodium drug used in present study is a beta-lactam antibiotic classified as a third generation cephalosporin used to treat infections caused by bacteria. It is a cephalosporin organic sodium salt. Cefotaxime sodium is the commercial name of the sodium salt of [6R-[6- α ,7 β (z)]-3-[(acetyloxy)methyl]-[(2-amine-4-thiazolyl)(methoxyimino)acetyl]amino]-8-oxo-5-thia-1-azabicyclo[4,2,0]oct-2-ene-2-carboxylic acid (29, 30). In this paper, investigation of the corrosion inhibition activity of expired cefotaxime sodium drug is investigated towards surface of mild steel in 0.5 M H₂SO₄ using weight loss and electrochemical studies. Structure of the molecule is given in Figure 1 which has a molecular formula of C₁₆H₁₆N₅NaO₇S₂.

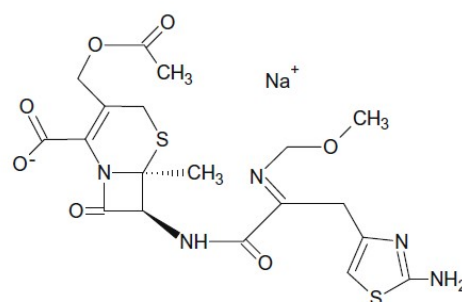


Figure 1: Chemical structure of cefotaxime sodium.

EXPERIMENTAL

Inhibitor

Cefotaxime sodium was procured from a common medicine shop and kept till the expiry date is over and the stock solution of this compound is made with water for all the experiments using dilution method for various concentrations of inhibitors (29)

Corrosion measurements

Corrosion measurements will be done on mild steel having composition (wt%) P=0.03; Mn=0.035; C=0.14; S=0.025; Si=0.17; and Fe (remains). The mild steel surface duly cleaned by emery papers and cleaned with deionized water. Acetone is used for degreasing process and the samples were further dried in hot air blower and placed in desiccator for experiments.

Weight loss technique

This study is performed on mild steel of 10 cm² area and having rectangular shape in 100 mL of acidic solution in various concentrations of inhibitors (from zero to optimum) at different temperature ranges. All the experiments were done in triplicate and the results are found to be a deviation of less than 0.1% which is due to manual error. To minimize the discrepancy, weight loss average in each condition has been taken in consideration for the calculation of different parameters. %Inhibition efficiency, corrosion rate, surface coverage, and calculation of thermodynamic and adsorption parameters were calculated as mentioned in literature (31), (32).

$$I. E. (\%) = \frac{W_0 - W_i}{W_0} \times 100 \quad (1)$$

$$\Theta = \frac{W_0 - W_i}{W_0} \quad (2)$$

W_0 = weight loss of metal in the absence cefotaxime sodium,
 W_i = Weight loss in the presence of cefotaxime sodium.

Electrochemical techniques

Polarization resistance, Tafel polarization, and EIS is conducted three electrode assembly where calomel electrode acts as reference electrode, platinum as the counter electrode, and metal sample for test as the working electrode. Working electrode area will be 1 cm². Gamry Instruments potentiostat / galvanostat with Gamry frame work system on ESA 400 for all the electrochemical studies and analysis will be done through Echem analyst version 5.50 software packages for data fitting. All the measurements will be done with the parameters reported in literature (21, 33, 34). All electrochemical studies like linear polarization, Tafel polarization and electrochemical impedance spectroscopy has been reproduces before reporting the results.

RESULTS & DISCUSSIONS

Weight loss measurements:

Weight loss measurement of the metal strip is used to calculate inhibition efficiencies (η %), corrosion rates (C_r , in mmpy), and surface coverage (θ) for varying temperatures and they are reported in Table 1. Inhibition efficiency of the cefotaxime sodium increases with the increase in the inhibitor concentration from 0 to 4.5×10^{-4} M. It was apparent from the Table 1 that while varying the temperature from 298 K to 338 K of 0.5 M H₂SO₄ solution, efficiency of inhibitor was always the highest at 4.5×10^{-4} M inhibitor percentage whereas increasing the percentage of drug in concentration makes negligible change in efficiency either in positive or negative data change. The maximum inhibitor efficiency was found at 289 K to be 95.7%, but it seems to be decreasing at various increasing temperature change in 4.5×10^{-4} M inhibitory mixture, so 4.5×10^{-4} M inhibitory percentage was found to be the best suited amount in mixture to provide 95.5% inhibitory efficiency at 298 K temperature. This inhibitory action is caused by the molecular adsorption of cefotaxime sodium on the surface of mild steel. Adsorption may be due to both π -electrons and non-bonding lone pair of electrons. These properties can also be responsible for the inhibitive action. The same has been plotted in Figures 2 and 3 report the required inhibitor efficiency at varying temperature range of mixture with respect to inhibitor efficiency and corrosion rate, respectively.

Table 1: Weight loss measurement data in absence and presence of cefotaxime sodium in towards mild steel in the aqueous solution of 0.5 M sulfuric acid.

Temperature (K)	Concentration of inhibitor (M)	Weight loss (in mg cm ⁻¹)	Inhibition efficiency (η) (%)	Corrosion rate (C _r) (mm/y)	Surface coverage (θ)
298	Blank	14.00	-	52.14	-
	0.5×10^{-4}	5.59	60.1	20.81	0.601
	1.0×10^{-4}	4.54	67.6	16.89	0.676
	1.5×10^{-4}	3.42	75.6	12.72	0.756
	2.0×10^{-4}	2.60	81.4	9.70	0.814
	2.5×10^{-4}	1.97	85.9	7.35	0.859
	3.0×10^{-4}	1.39	90.1	5.16	0.901
	3.5×10^{-4}	0.95	93.2	3.55	0.932
	4.0×10^{-4}	0.63	95.5	2.35	0.955
	4.5×10^{-4}	0.60	95.7	2.24	0.957
308	Blank	17.17	-	63.94	-
	0.5×10^{-4}	8.03	53.2	29.92	0.532
	1.0×10^{-4}	6.40	62.7	23.84	0.627
	1.5×10^{-4}	4.87	71.7	18.13	0.717
	2.0×10^{-4}	3.67	78.6	13.66	0.786
	2.5×10^{-4}	2.97	82.7	11.05	0.827
	3.0×10^{-4}	2.27	86.7	8.44	0.868
	3.5×10^{-4}	1.73	89.9	6.46	0.899
	4.0×10^{-4}	0.97	94.4	3.60	0.944
	4.5×10^{-4}	0.97	94.4	3.60	0.944
318	Blank	26.05	-	97.01	-
	0.5×10^{-4}	13.44	48.4	50.06	0.484
	1.0×10^{-4}	11.62	55.4	43.27	0.554
	1.5×10^{-4}	9.87	62.1	36.77	0.621

	2.0×10^{-4}	7.79	70.1	29.00	0.701
	2.5×10^{-4}	5.89	77.4	21.92	0.774
	3.0×10^{-4}	4.32	83.4	16.10	0.834
	3.5×10^{-4}	3.28	87.4	12.22	0.874
	4.0×10^{-4}	2.29	91.2	8.54	0.912
	4.5×10^{-4}	2.55	90.2	9.50	0.902
328	Blank	33.74	-	125.66	-
	0.5×10^{-4}	19.57	42	72.88	0.420
	1.0×10^{-4}	17.71	47.5	65.97	0.475
	1.5×10^{-4}	15.39	54.4	57.30	0.544
	2.0×10^{-4}	12.85	61.9	47.88	0.619
	2.5×10^{-4}	11.34	66.4	42.22	0.664
	3.0×10^{-4}	9.28	72.5	34.56	0.725
	3.5×10^{-4}	7.29	78.4	27.14	0.784
	4.0×10^{-4}	7.25	78.5	27.02	0.785
	4.5×10^{-4}	7.05	79.1	26.26	0.791
338	Blank	43.06	-	160.38	-
	0.5×10^{-4}	31.22	27.5	116.27	0.275
	1.0×10^{-4}	27.82	35.4	103.60	0.354
	1.5×10^{-4}	24.37	43.4	90.77	0.434
	2.0×10^{-4}	21.49	50.1	80.03	0.501
	2.5×10^{-4}	19.29	55.2	71.85	0.552
	3.0×10^{-4}	15.42	64.2	57.41	0.642
	3.5×10^{-4}	14.68	65.9	54.69	0.659
	4.0×10^{-4}	14.60	66.1	54.37	0.661
	4.5×10^{-4}	15.29	64.5	56.93	0.645

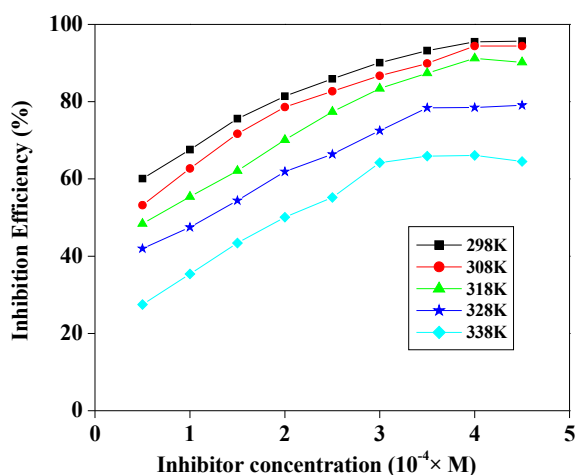


Figure 2: Inhibitor efficiency at varying temperatures on standard find concentration of the inhibitor.

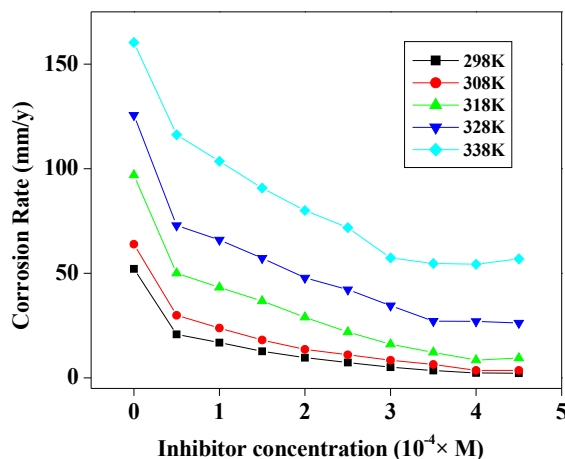


Figure 3: Corrosion rate at varying temperatures at various concentrations of cefotaxime sodium.

Effect of solution temperature on the adsorption isotherm

It is crucial to understand how organo-electrochemical reactions work through adsorption isotherms. It was tested using different isotherms by C_{inh} vs C_{inh}/θ graph (3, 35), for the experimental results presented in this trial, Langmuir adsorption isotherm was considered adequate due to most linear representation of regression coefficient (R^2). A mild steel plate, already discussed above, has been initiated for test in 0.5 M H_2SO_4 solution with 0.5×10^{-4} M inhibitor concentration in combination with the steel surface at a varying temperature range from 298 K -338 K and represented in Figure 4,

which shows the linear regression coefficient and slope of the graph. The values of R^2 listed in Table 2 range from 0.99765 to 0.98973 to extend the temperature range of the mixture from 298-338 K. Due to the presence of n-electrons, and a quaternary nitrogen atom, it has proved perfectly suited for 4.0×10^{-4} M at a temperature of 298 K at the MS surface. Desorption of inhibitor may be the reason for this phenomenon. The $-\Delta G_{ads}$ values have been calculated and reported in Table 2, and they are between $31.13 \text{ kJ mol}^{-1}$ to $38.34 \text{ kJ mol}^{-1}$, corresponding to a range of 20 to 40 kJ mol^{-1} . This suggests that the inhibitor is adsorbed on the metal surface is physically (36).

Table 2: Adsorption parameters of cefotaxime sodium on mild steel surface at different temperature ranges.

Temperature (K)	K_{ads} (Mol^{-1})	Slope	R^2	$-\Delta G_{ads}$ ($KJ \text{ mol}^{-1}$)
298	5.1×10^3	0.94	0.99765	31.13
308	6.4×10^3	0.92	0.99793	32.72
318	8.5×10^3	0.92	0.99332	34.56
328	9.9×10^3	1.04	0.99281	36.07
338	1.5×10^4	1.16	0.98973	38.34

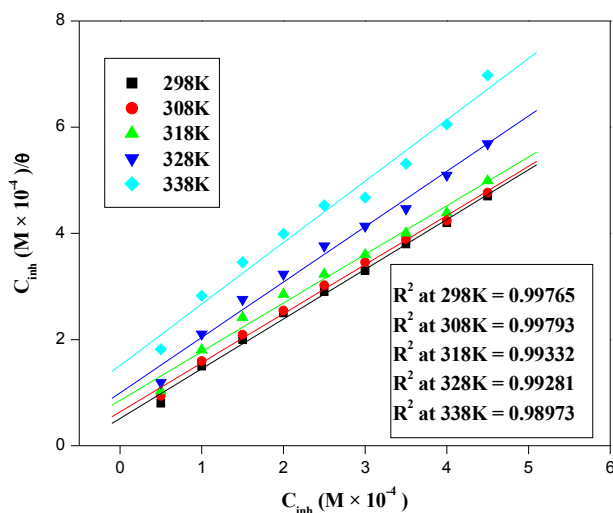


Figure 4: Langmuir's adsorption isotherm for different concentrations of cefotaxime sodium in 0.5 M sulfuric acid solution.

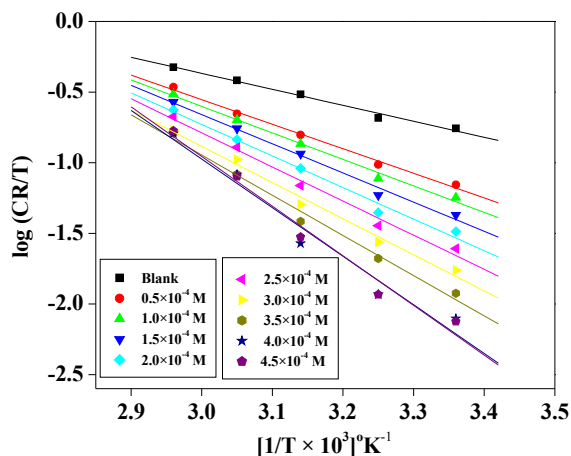


Figure 5: Transition state graph in the absence and presence of different concentrations of cefotaxime sodium for mild steel corrosion in 0.5 M sulfuric acid.

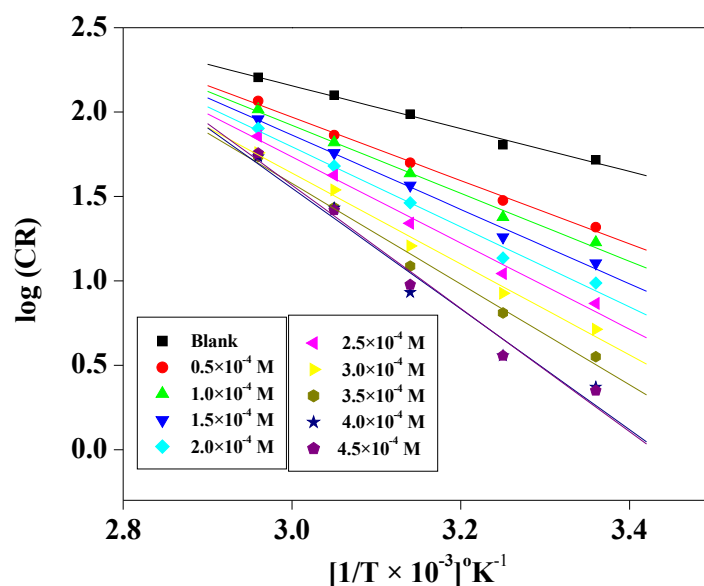


Figure 6: Arrhenius' plot of the cefotaxime sodium in 0.5 M sulfuric acid solution.

Activation parameters on the inhibition process

Temperature of the solution is key to understand the inhibitive process of corrosion. For observing the effect of temperature samples has been tested at 298 to 338 K for different concentrations of the cefotaxime sodium and inhibition efficiency and corrosion rate has been calculated and listed in Table 1. Corrosion rate at various temperatures of solution and concentration of inhibitors are correlated with the Arrhenius equation to express the relationship of corrosion rate with the temperature of acidic media (37-40).

$$\log(C_r) = \frac{-E_a}{2.303 RT} + \log \lambda \quad (\text{Eq. 3})$$

Where E_a = apparent effective activation energy,
 R = molar gas constant
 λ = Arrhenius' pre exponential factor.

A graph of CR Vs. $1/T$ has been plotted in Figure 6 which shows the regression coefficient approximately very close to unity. E_a values are calculated from the slope of the curve. The slope of the curve is equivalent to $-E_a/2.303 R$ and λ value can be calculated from the intercept which is equivalent to the $\log \lambda$. Calculated values of these two has been listed in Table 3. Value of activation energy is more than that of uninhibited sample and increasing though out the increment of the inhibitor concentration suggested that the adsorption of the inhibitor on the mild steel surface is physical adsorption. Subsequent increase in the activation energy also suggests that the inhibitor is less effective on increasing temperature towards the mild steel surface at 0.5 M sulfuric acid medium. As per observation of Arrhenius equation it is found that the corrosion rate is also influence by λ increasing the value decreases the corrosion rate (41).

Table 3: Thermodynamic parameters in absence and presence different concentration ranges of cefotaxime sodium for mild steel.

Concentration of inhibitor (M)	E_a (kJ mol ⁻¹)	λ (mg cm ⁻²)	ΔH (kJ mol ⁻¹)	ΔS (J mol ⁻¹ K ⁻¹)
Blank	24.29	9.14×10^5	21.68	-142.25
0.5×10^{-4}	35.92	3.95×10^7	33.30	-110.93
1.0×10^{-4}	38.54	9.10×10^7	35.92	-103.99
1.5×10^{-4}	42.19	2.98×10^8	39.58	-94.12
2.0×10^{-4}	45.41	8.11×10^8	42.80	-85.81
2.5×10^{-4}	48.86	2.45×10^9	46.25	-76.60
3.0×10^{-4}	51.58	5.24×10^9	48.96	-70.29
3.5×10^{-4}	57.11	3.35×10^{10}	54.50	-54.86
4.0×10^{-4}	68.49	1.90×10^{12}	65.88	-21.27
4.5×10^{-4}	69.91	3.32×10^{12}	67.30	-16.65

Value of enthalpy of activation (ΔH) and entropy of complex in transition state equation can be activation (ΔS) for the formation of the activated

calculated by alternative Arrhenius equation i.e. transition state equation (42, 43).

$$C_r = \frac{RT}{Nh} \exp\left(\frac{\Delta S}{R}\right) \exp\left(\frac{-\Delta H}{RT}\right) \quad (4)$$

Where h = Planck's constant,
N = Avogadro's number,
 ΔS = entropy of activation
 ΔH = enthalpy of activation.

A graph of $\log (CR/T)$ versus $1/T$ has been plotted as represented in Figure 5 which is a straight line. Values of enthalpy of activation (ΔH) and entropy of activation (ΔS) has been calculated from the slope and intercept of the curves and listed in Table 3. As per Table 3, in the inhibition process the value of the enthalpy is increasing with the increase in the inhibitor concentration. The positive value of enthalpy of activation reflects that the corrosion inhibition phenomenon is endothermic and dissolution of metal is difficult by increasing the inhibitor concentration (44). Higher protection efficiency is due to the presence of energy barrier for the reaction.

Entropy of activation (ΔS) is increasing with an increase in the inhibitor concentration as compared to the compared to free acid solution. Increased entropy of activation in the presence of inhibitor indicated that disorderness is increased on going from reactant to activated complex. Therefore the inhibition efficiency will increase.

Linear Polarization technique

Linear polarization data were listed in Table 4. Polarization resistance value increases with increase in inhibitor concentration results the increase in inhibition efficiency of the inhibitor used in the study. Maximum inhibition efficiency is

approximately 93%, which is in good agreement with the inhibition efficiency exhibited in the weight loss studies.

Tafel Polarization

Measurements of polarization have been measured and documented. Figure 6 shows plots demonstrating the effect of cefotaxime sodium concentrations on the anodic and cathodic polarization actions of mild stain in 0.5 M H_2SO_4 solution. Table 4 shows the electrochemical properties of plots, such as the density of corrosion current (I_{corr}), the potential for corrosion (E_{corr}), the anodic slopes (b_a and b_c), the resistance to polarization (R_p), and the inhibitor performance (IE percent) (45). As seen in Table 4, the addition of cefotaxime sodium to the 0.5 M H_2SO_4 solutions inhibit both anodic metal dissolution and cathode hydrogen evolution. Table 4 demonstrates that, when the concentration of cefotaxime sodium was increased, the inhibition of these reactions became more pronounced. Without causing major improvements in the tendency for corrosion, the inhibitor results in a lower I_{corr} corrosion current density, indicating that a mixed form inhibitor (i.e. prevents both anodic and cathodic corrosion) is adsorbed on the surface, preventing corrosion (46). Without an inhibitor, the ability of mild steel became involved and changed to 455 mV (SCE) as a more negative value due to the dissolution of an air-molded oxide film, as seen in Figure 6. With the addition of an inhibitor to the solution, the potential shifted to the positive side, and the shift became more pronounced as the inhibitor's concentration rose. The established I_{corr} density decrease was detected as cefotaxime sodium levels increased, indicating that the inhibitor's inhibitory efficacy increased as the inhibitor's concentration increased. This is the beginning of the production of protective oxide-and-cefotaxime films.

Table 4: Potentiodynamic polarization parameters for cefotaxime sodium in sulfuric acid medium on mild steel surface.

Inhibitor Conc.	Tafel data					Linear Polarization data		
	$-E_{corr}$ (mV SCE)	vs	b_a (mV dec ⁻¹)	b_c (mV dec ⁻¹)	I_{corr} ($\mu A cm^{-2}$)	IE (%)	R_p (Ωcm^2)	IE (%)
Blank	455		63	137	1275	-	55.3	-
1.0×10^{-4}	457		71	147	478	62.5	137.3	59.7
2.0×10^{-4}	460		72	151	284	77.7	255.8	78.3
3.0×10^{-4}	462		71	144	175	86.3	398.1	86.1
4.0×10^{-4}	465		74	152	88	93.7	796.4	93.0

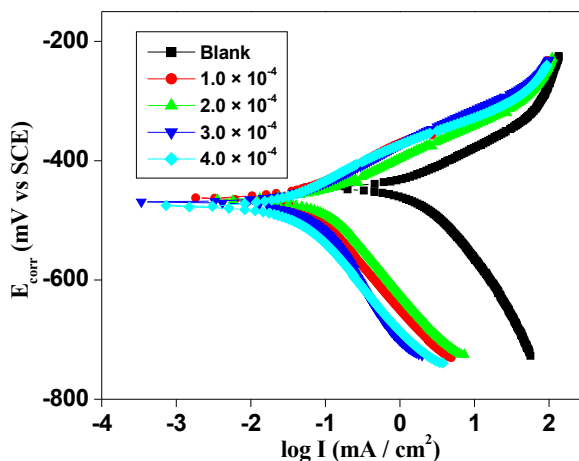


Figure 7: Tafel polarization curve with different concentrations of cefotaxime sodium on mild steel in 0.5 M sulfuric acid.

Electrochemical Impedance Spectroscopy techniques

Corrosion inhibition activity cefotaxime sodium was investigated using electrochemical impedance spectroscopy on mild steel surfaces in 0.5 M aqueous H₂SO₄ solution. Figure 7 depicts an impedance spectrum i.e. Nyquist plot mild steel corrosion where the depressed semicircles look like a depressed capacitive ring. A high frequency single semicircle, which can be transmitted via the loading phase of corrosion and the surface heterogeneity, is due to these factors which can be exacerbated by surface ruggedness, dislocations at the active site or adsorption by the inhibitor molecules represented in Figure 7. The impedance electrochemical data would be compared to F. Mansfeld's multiple theoretical circuits. The analogous circuit was applied at a

constant phase angle to demonstrate the impedance data applicable to the iron/acid interface model (47). For electrochemical impedance, the corresponding circuit parameters (R_s , R_t , Y_0 , and n) have been obtained and reported in Table 5.

The inhibitor's adsorption effect is similar to the impedance distribution on the metal surface. Adsorption of drug inhibitor molecules causes polarization resistance R_p , which increases with the number of adsorbed molecules. Furthermore, the adsorbed inhibitor film reduces capacitance at the metal-solution interface as a result of a reduction in the dielectric constant between metal and electrolyte and/or an improvement in thickness of metal (48–50).

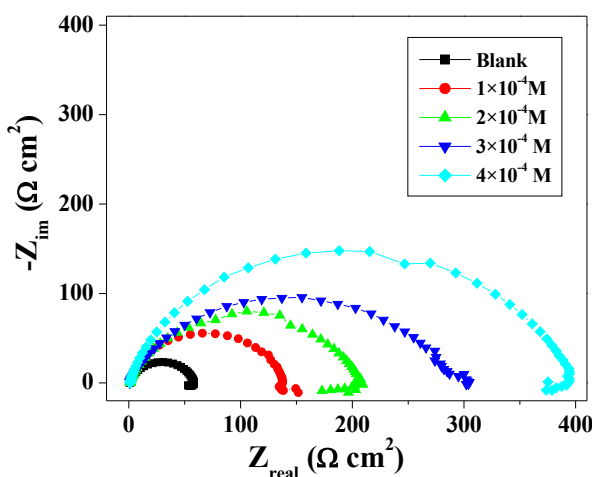


Figure 8: Nyquist plot of the electrochemical impedance spectroscopy curve of different concentrations of cefotaxime sodium on mild steel surface in 0.5 M sulfuric acid.

Table 5: Electrochemical impedance parameters values of cefotaxime sodium in 0.5M sulfuric acid

Inhibitor concentration (ppm)	R_s ($\Omega \text{ cm}^2$)	R_p ($\Omega \text{ cm}^2$)	Y_o ($\mu\text{F cm}^{-2}$)	N	C_{dl} ($\mu\text{F cm}^{-2}$)	IE (%)
Blank	1.13	53.3	1181.5	0.858	55	-
1.0×10^{-4}	1.07	141.8	205.7	0.836	48	62.4
2.0×10^{-4}	1.09	214.3	112.3	0.831	42	75.1
3.0×10^{-4}	0.96	309.9	87.5	0.825	38	82.8
4.0×10^{-4}	0.99	401.4	74.3	0.822	35	86.7

Surface Study (AFM)

Atomic force microscopic technique is used to know morphology of the surface of mild steel unexposed in corrosive environment, exposed in corrosive environment without inhibitor and with optimum concentration of cefotaxime sodium inhibitor and

the surface morphology is represented in Figure 8a-c. Surface roughness of untreated, uninhibited, and inhibited surface of mild steel are 51 nm, 590 nm, and 154 nm, respectively. Decrease in surface roughness shows the effectiveness of the cefotaxime sodium.

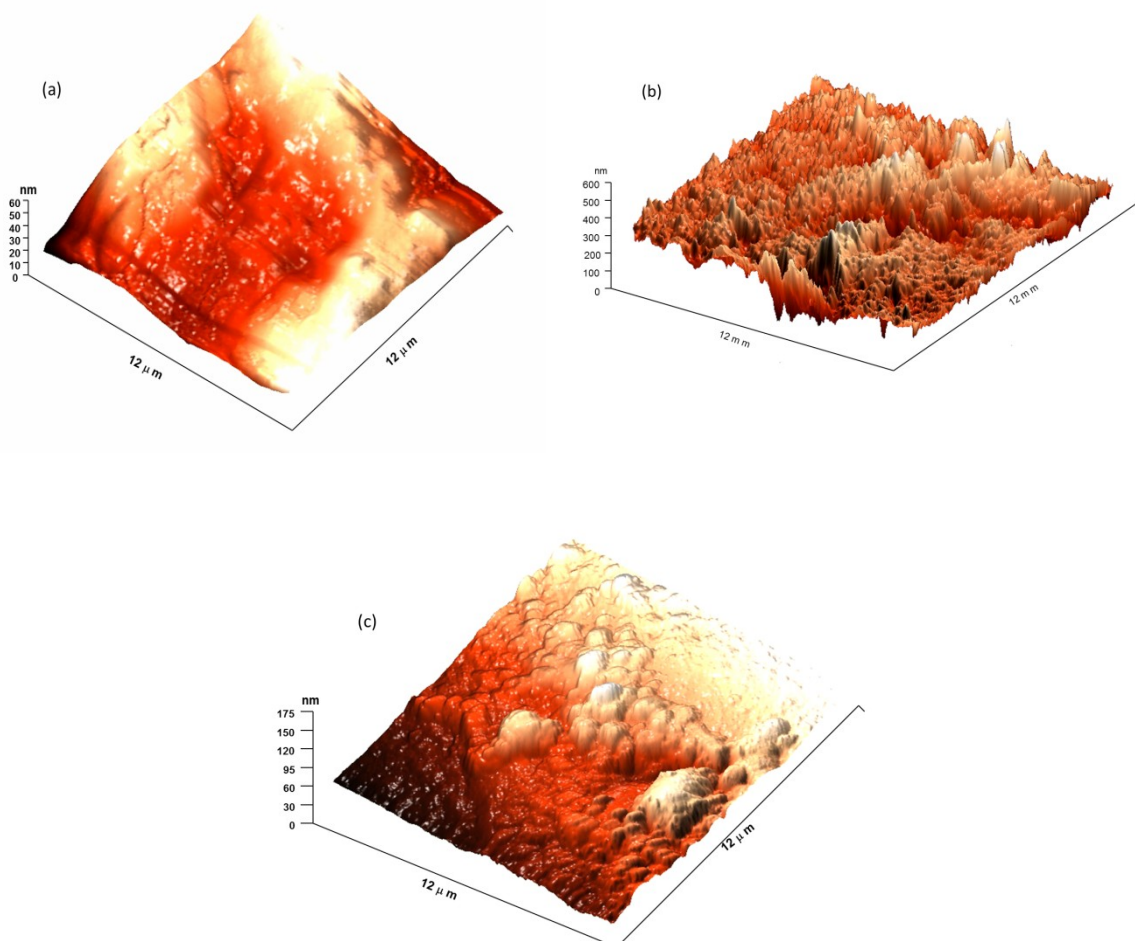


Figure 9: AFM studies of mild steel surface (a) polished surface, (b) surface exposed in corrosive medium without inhibitor, (c) surface exposed in corrosive medium with optimum concentration of cefotaxime sodium inhibitor.

CONCLUSION

- It is evident from all studies that cefotaxime sodium is good inhibitor for the surface of mild steel in 0.5M sulfuric acid medium.

- Increase in the temperature of the test solution results the decrease in the inhibitor efficiency suggest that it is a good inhibitor at lower temperature range.

- Electrochemical studies suggested that it is a mixed type of inhibitor and adsorbed on the surface in monolayer.
- Adsorption of cefotaxime sodium follows Langmuir adsorption isotherm.
- All the thermodynamic and adsorption parameters suggested that the interaction of the inhibitor on mild steel surface is of the physical adsorption type.

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