Inhibition of Acid Descaling and Pickling Effects on API 5CT Carbon Steel Using Schiff Base Ligand (C_{24}H_{21}N_{5}O_{2}) in 1 M H_{2}SO_{4} Solution

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ABSTRACT: The objective of this paper was to investigate the inhibition of acid descaling and pickling effects on API 5CT carbon steel using Schiff base ligand (C_{24}H_{21}N_{5}O_{2}) in 1 M H_{2}SO_{4} solution using Potentiodynamic Polarization (PDP), Electrochemical Impedance Spectroscopy (EIS) and Weight Loss (WL) techniques. FTIR spectroscopy shows that there was a strong adsorption of SFBL on the carbon steel surface due to formation of a complex surface film. Corrosion rate of carbon steel decreased exceedingly from 0.0155 to 0.0002 while inhibition efficiency of SFBL rose from 78.8 % to 98.9 % between 20 ppm and 100 ppm respectively. PDP measurements revealed a mixed type inhibitor. EIS measurement reveals that the increasing charge transfer resistance was directly proportional to the increase inhibitor concentration and the double layer capacitance dropped from 1.98 to 0.61 indicating a stronger inhibition.

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Metals are widely used in today’s world especially in the fields of engineering – shipping, building, construction, machining, automobile, petroleum, mining, etc (Ameh and Eddy, 2018; Ugi et al., 2024). The beauty and strength experienced from these metals while in use allow for its wider application. But the wide application of metal is truncated by the damage caused by corrosion effects. These aggressiveness from corrosion could tamper with the metal’s durability, tensile strength, malleability, ductility, conductivity, illustriousness, etc. Corrosion which is the deterioration of a metal under unfavorable environmental conditions (Ammouchi et al., 2020; Bashir et al., 2020; Ugi, 2021) has come a long way and seemed only to be managed as hopes of complete eradication of the effects is dripping off considering the different growing environmental conditions experienced today especially from greenhouse effects. The cause of corrosion is widely attributed to the chemistry involved – electro-chemical or chemical corrosion process and the processes involved in the preparation and treatment of these metals before their application, for instance during acid pickling, acidization, descaling, fracking processes, etc. (Bhuvaneswari et al., 2021; Diki et al., 2021). However, so much has been done in establishing an alternative means to combat corrosion effects through the deployment of chemical inhibitors. These type of inhibitors posed serious threat to the environment and the ecological system, they were expensive in production, difficult to secure (not easily assessable), and dangerous to health (Ugi and Ugi 2023). Schiff

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base ligands which are ecologically friendly are mostly in use today in the area of corrosion mitigation. Schiff bases are usually synthesized from the condensation of primary amines and active carbonyl groups. The azomethine linkage (HC=N) and the donor atoms in the backbone of the Schiff bases are responsible for their biological and industrial applications, which can be altered depending upon the type of substituent present on the aromatic rings. Moreover, the ionic exchange between the mild steel and hetero-atoms such as O, N, P, S and double/triple bonds or aromatic rings plays an important role in the adsorption process. These group of inhibitors are opted for because they do not posed any threat to the environment and the ecological system, they are not expensive in production, easily assessable, and harmless to both man and animal health (Ebenso et al., 2021; Erteeh et al., 2021; Ugi et al., 2021). The objective of this paper was to investigate the inhibition of acid descaling and pickling effects on API 5CT carbon steel using Schiff base ligand (C₃H₃N₃O₃) in 1 M H₂SO₄ solution.

MATERIAL AND METHODS
Preparation of Specimens: The API 5CT low carbon steel adopted for this work has the following composition by weight percentage: Si – 0.5, C – 1.5, Mn – 1.5, P – 0.022, S – 0.016 and the rest Iron. The carbon steel sheet was resized mechanically to a dimension of 5 x 4 x 0.012 cm and then polished with series of emery paper of variable grades starting with the coarsest and then proceeding in steps to the finest grade. They resized carbon steel coupons were later washed with distilled water, rinsed with absolute ethanol, dried in air after rinsing with acetone. For the electrochemical experiment, the carbon steel sheet was resized into a dimension of 1 x 1 cm and polished in preparation for the experiment using silicon carbide emery paper of different grades (400 to 1200 grit) and subsequently cleaned with acetone and rinsed with distilled water and stored. Serial dilution was used to prepare different concentrations of the Schiff base ligand inhibitor ranging from 20, 40, 60, 80 and 100 ppm.

Synthesis of Schiff base (C₂₃H₁₅N₅O₅): 5 g of 4-amino antipyrene at a concentration of 0.05 M was digested in a 50 ml methanolic solution of 5 g 4-(Benzeneazo) Salicylaldehyde and magnetically stirred using a 250 ml round bottom flask. This was followed by the addition of 2 ml acetic acid and refluxed for 6 hours and allowed to cool. A light green precipitate was obtained and then filtered, recrystallized with ethanol and oven dried at 60 OC. The chemical equation for the synthesis is shown in Figure 1.

The UV - 2500 PC and SHIMADZU FTIR-8400 spectrophotometers were used in the study of electronic spectra of compound and structural study respectively. This study was to enable the understanding of the active compound responsible for the adsorption. The process involved the immersion of the resized carbon steel sheets in 200 ml of 1 M H₂SO₄ acid solution containing the inhibitor and allowed for 72 hours, after which they were retrieved, dried, and the films scraped and used for the surface characterization according to previous studies of Ugi and Ugi (2024) and, Bhuvaraneswari (2021).

Gravimetric Technique: The gravimetric experiment was carried out using resized mirror-polished API 5CT Carbon Steel sheets, thermostated water bath, Mettler Toledo PB602 analytical weighing balance and glass wares at concentrations of 20 ppm, 40 ppm, 60 ppm, 80 ppm and 100 ppm respectively, according to previous works of Bhuvaraneswari (2021). The inhibition efficiency (IE), and degree of surface coverage (O) of mild steel in 1M HCl solution was computed using the formula as shown Equation 1 and 2 respectively.

\[ \% IE = \frac{(L)_0 - (L)_{inh}}{(L)_0} \times 100 \]  

(1)

Where: (L)₀ = corrosion rate of metal without Schiff base ligand inhibitor, (L) inh = corrosion rate of metal with Schiff base ligand inhibitor inclusive.

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\[ \theta = \frac{(i\omega)^{100}\ln h}{i\omega} \]  

(2)

Where all abbreviations are same as in equation 1.

**Electrochemical Measurements:** A computer-controlled potentiostat/galvanostat (Autolab PGSTAT 302N) consisting of saturated calomel electrode (SCE) as reference electrode (RE), platinum as counter electrode (CE) and API 5CT Carbon Steel sheets as working electrode (WE) was used. Before each potentiodynamic polarization (Tafel) study, the electrode was allowed to corrode freely and its open circuit potential (OCP) was recorded as a function of time up to 1 hour, which was sufficient to attain a stable state. Potentiodynamic polarization studies were conducted from cathodic to the anodic direction on the potential range ±250 mV versus corrosion potential (Ecorr) at a scan rate of 10 mV/s. Linear polarization resistance measurements (LPR) were performed at the potential range ±20 mV with respect to the open circuit potential, and the current response was measured at a scan rate of 0.5 mV/s. The EIS measurements were performed once the OCP was stabilized at a frequency range of 100 KHz to 10 MHz with a signal amplitude perturbation of 5 mV. The inhibition efficiency (%) was calculated using Equation 5.

Where \( A_{corr}^a = \) corrosion current densities in the absence of Schiff base ligand; \( A_{corr} = \) are the corrosion current densities in the presence of Schiff base ligand;

The polarization resistance was obtained using the Stern-Geary equation 4.

\[ R_p = \frac{G_a \times G_c}{2.303 \times \sqrt{G_a \times G_c}} \]  

(4)

Where \( G_a \) and \( G_c \) are the anodic and cathodic Tafel slopes. From the measured \( R_p \) values, the inhibition efficiency (%) was calculated using Equation 5.

\[ I(\%) = \left( \frac{R_p - R_p^o}{R_p} \right) \times 100 \]  

(5)

where \( R_p^o \) and \( R_p \) are the polarization resistance values in the absence and presence of inhibitors.

The constant phase element which is defined by \( Y_0 \) and \( n \) has correlation with the impedance as follows equation 6

\[ ZZ_{CPE} = Y_0^{-1}(j\omega)^{-n} \]  

(6)

where \( Y_0 \) is the CPE constant and \( n \) is the CPE exponent, \( j = (-1)^1 \) which is an imaginary number and \( \omega \) is the angular frequency in rad/s. The double layer capacitance \( (C_{dl}) \) values were calculated from equation 7 expression.

\[ C_{dl} = \frac{1}{\omega R_{ct}} = \frac{1}{(2\pi f_{max} R_{ct})} \]  

(7)

Where \( \omega \) is the angular frequency \( (\omega = 2\pi f_{\text{max}}) \), \( f_{\text{max}} \) is the frequency at which the imaginary component of the impedance is maximum. The inhibition efficiency acquired from the impedance spectroscopy measurements were calculated using equation 8:

\[ \%IE = \frac{U_{ct(\text{inh})} - U_{ct(\text{nh})}}{U_{ct(\text{nh})}} \times 100 \]  

(8)

Where \( U_{ct(\text{nh})} \) and \( U_{ct(\text{inh})} \) are the charge transfer resistance in the presence and absence of inhibitor, respectively.

**RESULTS AND DISCUSSION**

Electronic spectra of the Schiff base ligands: SBL2 showed three essential absorption bands at 248.4 nm (40081.16 cm\(^{-1}\)), 274.1 nm (36362.54 cm\(^{-1}\)), and 321.4 nm (31200.23 cm\(^{-1}\)). The band appearing at lower energy (248.4 and 274.1 nm) was indicative of a \( n - \pi^* \) transition due to the nonbonding electrons present on the nitrogen atom of the -HC=N group and the phenolic group. The band observed at higher energy (321.4 nm) was consequent of \( \pi - \pi^* \) transition of the ligand centered transitions of benzene ring (Fouda et al., 2021; Liu et al., 2020; Haruna and Saleh, 2022).

**FT-IR spectral analysis:** Peaks attributable to the functional groups were shown from the observed infrared spectra. The efficacy of the Schiff base to adsorb strongly on the carbon steel was evident by the presence of the identified functional groups. The spectra of the SFBL as well as corrosion products from the inhibitor films on the carbon steel surface are presented in Figures 2-3. Table 1 represent data generated from the infrared absorption spectra SFBL and their corrosion products. From Table 1, the C=N at 1580 and 1618 cm\(^{-1}\) was shifted to 1625 and 1595 cm\(^{-1}\), C–O stretch at 1327 cm\(^{-1}\) was shifted to 1329 and 1364 cm\(^{-1}\), C–C bend at 835 cm\(^{-1}\) was shifted to 880 and 828 cm\(^{-1}\), C–C stretch at 1439 and 1416 cm\(^{-1}\) was shifted to 1424 and 1491 cm\(^{-1}\), C–H stretch at 2097 and 2937 cm\(^{-1}\) was shifted to 2922 and 2072 cm\(^{-1}\), C–N stretch at 1088 and 1081 cm\(^{-1}\) was shifted to 1096 cm\(^{-1}\), O–H stretch at 3250 and 3370 cm\(^{-1}\) was shifted to 3161 and 3116 cm\(^{-1}\). The shifts in
frequencies indicated that there was an interaction between the mild steel surface and the Schiff bases (Fouda et al., 2021; Liu et al., 2020). On the other hand, C=C stretch at 1505.80 cm\(^{-1}\), C-H stretch at 2065 cm\(^{-1}\) and the C-H bend in the region 999 - 917 cm\(^{-1}\) were missing in the spectrum of the corrosion products suggesting that these functional groups were used for the adsorption of the inhibitor onto the surface of the carbon steel. This also indicated that some new bonds were also formed through these functional groups (Haruna and Saleh, 2022). Hence, protection of metallic surface was done via the functional groups presented in the inhibitor.

![Fig. 2. FTIR spectra of SFBL](image)

**Fig. 2.** FTIR spectra of SFBL

![Fig. 3. FTIR spectra of the corrosion product of API 5CT carbon steel in 1 M H\(_2\)SO\(_4\) in the presence of Schiff base ligand](image)

**Fig. 3.** FTIR spectra of the corrosion product of API 5CT carbon steel in 1 M H\(_2\)SO\(_4\) in the presence of Schiff base ligand

**Table 1.** The Relevant Infrared Spectra Data for the Schiff base Ligands cm\(^{-1}\)

<table>
<thead>
<tr>
<th>Compound</th>
<th>C-H</th>
<th>C-C</th>
<th>C-O</th>
<th>C-N</th>
<th>C=N</th>
<th>O-H</th>
<th>C-H bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFBL</td>
<td>2937</td>
<td>1416</td>
<td>1327</td>
<td>1081</td>
<td>1618</td>
<td>3370</td>
<td>835</td>
</tr>
<tr>
<td>SFBL = CS</td>
<td>2072</td>
<td>1491</td>
<td>1364</td>
<td>1096</td>
<td>1595</td>
<td>3116</td>
<td>828</td>
</tr>
</tbody>
</table>

**Weight Loss Measurements:** The Schiff base ligand demonstrated high adsorption tendency on the API 5CT carbon steel surface which was expressed in the high inhibition efficiency of the inhibitor (98.9 %) and decreased corrosion rate of the metal (0.0002 (g cm\(^{-2}\) hrs\(^{-1}\)) x 10\(^{-2}\)) as displayed in Table 2. This behaviour is always attributed to direct proportionality between increase inhibitor concentration and surface coverage (Ugi et al., 2024; Majda et al., 2020; Onyeachu et al., 2021). It could also be due to, the high molecular weight and the presence of abundant electron donation groups (C=N, O-H, C-N, N=N and aromatic rings). Since corrosion is an anodic site dissolution, a consequence of oxidation at the electrode, the increased inhibition efficiency with direct increase in inhibitor concentration implies that the corrosion active sites where the anions (SO\(_4^{2-}\)) are concentrated were strongly inhibited from oxidation (Ugi et al., 2024; Majda et al., 2020; Onyeachu et al., 2021). Hence there was no possibility of sulphate ions which pair up to form sulphate gas, that speed up corrosion activities on the API 5CT carbon steel surface.

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Table 2: Deduced data for corrosion rate and inhibition efficiency obtained from gravimetric method for API 5CT carbon steel in 1 M H_2SO_4.

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Weight Loss (g)</th>
<th>Corrosion Rate (g/cm²·h)</th>
<th>Inhibition Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>0.0155</td>
<td>0.189</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>0.0033</td>
<td>0.040</td>
<td>78.8</td>
</tr>
<tr>
<td>40</td>
<td>0.0021</td>
<td>0.026</td>
<td>86.2</td>
</tr>
<tr>
<td>60</td>
<td>0.0011</td>
<td>0.013</td>
<td>93.1</td>
</tr>
<tr>
<td>80</td>
<td>0.0009</td>
<td>0.011</td>
<td>94.2</td>
</tr>
<tr>
<td>100</td>
<td>0.0002</td>
<td>0.002</td>
<td>98.9</td>
</tr>
</tbody>
</table>

PDP Measurements: The Tafel slope for the API 5CT carbon steel in 1 M H_2SO_4 solution and varying concentrations of Schiff base where PDP parameters were calculated out of is presented in Fig. 4. The possible equation showing the anodic oxidation of iron in the API 5CT carbon steel due to chloride effect and that of the cathode reduction are shown in Equations 9-10 (Uwah et al., 2012; Padash et al., 2020).

\[
Fe(s) \rightarrow Fe^{2+}_{aq} + 2e^- \quad (9)
\]

\[
2H^+_{aq} + 2e^- \rightarrow H_2(g) \quad (10)
\]

From Table 3, it was observed that the corrosion current density (A_corr) values decreased with an increase in inhibitor concentration compared to the free acid solution. This is due to formation of adsorbed protective film of the Schiff bases on API 5CT carbon steel (Rbaa et al., 2020; Sharma et al., 2021; Ugi et al., 2022). The Ecorr values obtained from the analysis suggest that the Schiff base inhibitor have dominant influence on the partial anodic and cathodic reaction. The addition of the Schiff base inhibitor further shifted the corrosion potential (E_corr) towards negative values much less than -85 mV/SCE, hence acted as a mixed type inhibitor (Ebenso et al., 2021). The values of Gc and Ga obtained change on addition of inhibitor from that of the free acid solution (Table 3.). The calculated inhibition efficiency also increased with an increase in concentration of the inhibitor, similar to EIS results. The values of polarization resistance were observed to increase with corresponding increase in inhibition efficiency of the inhibitor as shown in Table 3. This result is in conformity with those of potentiodynamic polarization and electrochemical impedance spectroscopy. This phenomena is always in tandem with the theory of strong inhibitor molecular adsorption on surface of the API 5CT carbon steel (Ameh and eddy 2018; Ugi et al., 2024).

Table 3: PDP parameters for API 5CT carbon steel in 1 M H_2SO_4 in the absent and presence of SFBL.

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>E_corr (mV)</th>
<th>A_corr (µA)</th>
<th>G_L(V/dec)</th>
<th>G_C(V/dec)</th>
<th>η%</th>
<th>R_p (Ωcm²)</th>
<th>η%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>510</td>
<td>116</td>
<td>114.01</td>
<td>107.11</td>
<td>-</td>
<td>1.009</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>542</td>
<td>519</td>
<td>133.07</td>
<td>126.85</td>
<td>77.65</td>
<td>5.004</td>
<td>79.84</td>
</tr>
<tr>
<td>100</td>
<td>574</td>
<td>997</td>
<td>169.29</td>
<td>199.72</td>
<td>88.37</td>
<td>9.208</td>
<td>89.04</td>
</tr>
</tbody>
</table>

EIS Measurement: In order to access the inhibitor (Schiff bases) viability in creating a resistance on charge transfer between the working electrode and solution, the Nyquist plot as shown in Figure 5 was obtained. The various data calculated from the plots are presented in Table 4. From the Nyquist plots, it was observed that the diameter of the semicircles obtained were influences by both the free acid and the various concentrations of the Schiff base inhibitor. The difference in sizes of their diameters could be attributed to the strong adsorption of the Schiff base on the working electrode (API 5CT carbon steel), hence increasing the charge transfer resistance (R_u) at the working electrode and decreasing the solution resistance (R_s) of the electrolyte as concentration of the inhibitor increases (Agwamba et al., 2022; Ugi et al., 2025; 2020; Nya et al., 2018). However, the addition of SFBL further increased the diameter of the capacitive loop (Figure 5). The EIS plots were noticed to show some level of imperfection and a single capacity loop and could be linked to API 5CT carbon steel surface roughness, noise effects and a charge transfer type (process) of mechanism of inhibition (Agwamba et al., 2022; Ugi et al., 2025; 2020; Nya et al., 2018). The degree of roughness or non-homogeneity (n1) of API 5CT carbon steel was found to decreased on addition of SFBL, suggesting that the surface roughness of the steel was decreased on
Adsorption of inhibitor molecules on steel surface active sites and this result is in agreement with those of the morphology (SEM) test (Ugi and Magu 2012; Tan et al., 2020). A decrease in n on addition of inhibitors also signified insulation of the metal/solution interface by formation of a surface film. Formation of this film resulted in increase in charge transfer resistance in the presence than in the absence of inhibitor. The inhibition efficiency obtained also increased with increase in inhibitor concentration, hence consistent with weight loss results. The C_{ad} values decreased in the presence of inhibitors and could be attributed to a decrease in the local dielectric constant or increase in the thickness of the double layer or both, caused by the adsorbed protective film of the inhibitors as earlier inferred (Su et al., 2020; Ugi 2014; Uwah et al., 2013; Ugi et al., 2016).

From Table 5, it can be deduced that the data from the interaction between the Schiff base ligand and the API 5CT carbon steel surface fitted very well to the Langmuir than the Frumkin isotherm considering their correlation coefficient values. The Langmuir correlation values were 0.99 across the various temperatures which implies that the inhibition process was a physically adsorbed one and connotes a monolayer adsorption process (Ugi 2024; Nya et al., 2018; Ammouchi et al., 2020). From the Frumkin adsorption data, the interaction parameter values were all positive implying that there was a strong inhibitor molecular interaction between the Schiff base and the carbon steel. The values of the binding constant decreased while temperature was increased. This follows the possible desorption of Schiff base molecules from the API 5CT carbon steel surface at higher temperatures due to strong heat agitation of surface interaction.

Table 4. EIS parameters for API 5CT carbon steel in 1 M H_2SO_4 containing different concentrations of SFBL

<table>
<thead>
<tr>
<th>EIS Parameters</th>
<th>1 M H_2SO_4</th>
<th>20 ppm</th>
<th>100 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>U_c (Ωcm²)</td>
<td>18.9</td>
<td>39.4</td>
<td>99.3</td>
</tr>
<tr>
<td>R_c (Ωcm²)</td>
<td>1.34</td>
<td>1.30</td>
<td>1.16</td>
</tr>
<tr>
<td>Y_s x 10^4</td>
<td>7.96</td>
<td>0.77</td>
<td>0.20</td>
</tr>
<tr>
<td>Y_s (Ωs/cm^2) x 10^4</td>
<td>2.26</td>
<td>1.46</td>
<td>1.00</td>
</tr>
<tr>
<td>n_c x 10^1</td>
<td>8.53</td>
<td>8.18</td>
<td>7.97</td>
</tr>
<tr>
<td>R_c (Ωcm²)</td>
<td>4.20</td>
<td>0.42</td>
<td>0.74</td>
</tr>
<tr>
<td>Y_s (Ωs/cm^2) x 10^2</td>
<td>5.31</td>
<td>4.17</td>
<td>0.83</td>
</tr>
<tr>
<td>C_d (µF) x 10^-2</td>
<td>1.87</td>
<td>0.84</td>
<td>0.50</td>
</tr>
<tr>
<td>η%</td>
<td>-</td>
<td>52.03</td>
<td>80.97</td>
</tr>
</tbody>
</table>

Adsorption Isotherm: In order to understand the nature of adsorption whether physical (mono layer) or chemical and to further investigate the molecular interaction of the inhibitor while on the metal surface, the Langmuir and Frumkin adsorption isotherms were used. The Langmuir adsorption isotherm was deduced for the plot of \( \frac{C}{θ} \) vs C using equation 11 (Zaher et al., 2020; Ebenso et al., 2021; Ugi and Abeng 2013; Ugi et al., 2016).

\[
\frac{C}{θ} = \frac{1}{K} + C \quad (11)
\]

Where C is the inhibitor concentration and K the binding constant of corrosion inhibition process.

Of greater significance in applying the Frumkin adsorption isotherm is the molecular interactive parameter ‘a’. This parameter establishes the strength of attractive forces binding the Schiff base molecule to the API 5CT carbon steel surface and the parameter can either be negative or positive in action. Positive or negative values suggest strong attraction or repulsive (weak) forces between adsorbed molecules respectively (Ugi et al., 2019; Ugi 2021; Su et al., 2020; Joshi et al., 2021). This molecular interaction parameter was determined from the slope of the plot of surface coverage, θ vs. log C (g/L) according to the Frumkin Equation 12.

\[
\ln (\frac{θ}{1-θ}) = lnK_{ads} + 2aθ \quad (12)
\]

Where, θ is surface coverage, ‘a’ is interaction parameter, K_{ads} is the equilibrium constant and C is the Schiff base concentration.

Fig. 5. Nyquist plot for inhibition of API 5CT carbon steel in 1 M H_2SO_4 in the absence and presence of SFBL.

Table 5. Langmuir and Frumkin adsorption isotherm data for API 5CT carbon steel in 1 M H_2SO_4 solution

<table>
<thead>
<tr>
<th>Temp. (K)</th>
<th>K_{ads}</th>
<th>R^2</th>
<th>Slope</th>
<th>ΔG^*_ads (kJ/mol)</th>
<th>K_{ads}</th>
<th>a</th>
<th>R^2</th>
<th>ΔG^*_ads (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>303</td>
<td>23.87</td>
<td>0.9993</td>
<td>1.06</td>
<td>-4.442</td>
<td>2.23</td>
<td>43.1</td>
<td>0.8571</td>
<td>-13.34</td>
</tr>
<tr>
<td>313</td>
<td>9.06</td>
<td>0.9959</td>
<td>1.12</td>
<td>-3.184</td>
<td>1.92</td>
<td>47.8</td>
<td>0.8571</td>
<td>-12.15</td>
</tr>
<tr>
<td>333</td>
<td>3.04</td>
<td>0.9514</td>
<td>1.18</td>
<td>-1.713</td>
<td>1.92</td>
<td>47.8</td>
<td>0.8865</td>
<td>-11.76</td>
</tr>
</tbody>
</table>

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This result alongside those of the adsorption free energy ($\Delta G_{ads}$ (kJ/mol) showing values < -40 kJmol$^{-1}$ explains a physical adsorption mechanism and stronger inhibition at lower temperatures (Nya et al., 2018; Ammouchi et al., 2020)

**Conclusion:** The various experimental results affirmed the synthesized Schiff base ligand (C$_2$H$_3$N$_2$O$_2$) to be very effective in the corrosion inhibition arising from H$_2$SO$_4$ acid descaling and pickling effects on API 5CT Carbon Steel. Inhibition was confirmed to be through strong inhibitor molecular adsorption by a physical adsorption mechanism. The Schiff base ligand provided a stabilized inhibitor - API 5CT carbon steel surface adsorption, spontaneous reaction, strong molecular interaction and mono layer adsorption.

**Conflicts of Interest:** Authors clearly state that there is no any personal circumstances or interests that may be identified as inappropriately affecting the representation or explanation of reported research results.

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