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Response Evaluation of Mild Steel Corrosion Rate in H_2SO_4 to the Synegistic Influenceof Exposure Time and Steel Weight Loss

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Abstract: The response of mild steel corrosion rate in 0.5M H_2SO_4 (while in contact with an indicator- Hibiscus Sabdariffa) to the synergistic influence of exposure time and weight loss of the steel has been successfully evaluated. The predictive evaluation was carried out using a derived empirical model;

$$\xi = \text{Ꜧ}\,(-\,\text{ß}\text{ɤ}^2 + \text{Ɵ}\text{ɤ} - N\tau^2 + \Phi\tau + \check{G})$$

Prior to derivation of the empirical model, mild steel was submerged in 0.5M H_2SO_4 containing an inhibitor; sabdariffa leaf extract which strived to resist corrosion of the steel. In the course of the model derivation, applied ranges of values of the process parameters: corrosion rate, exposure time and weight loss were 0.6916 – 0.7086 mm/yr, 0.00548 – 0.0164yr and 0.0799 -0.2456g respectively. Results generated were based on weight-loss method. The validity of the derived model is strongly rooted on the core model structure; $(\xi/\text{Ꜧ}) - \check{G} \approx -\,\text{ß}\text{ɤ}^2 + \text{Ɵ}\text{ɤ} - N\tau^2 + \Phi\tau$.. The model-predicted results agree with previous research on the polynomial relationship between the corrosion rate and exposure time & mild steel weight loss, while inhibitor concentration is constant. The standard error associating model prediction of corrosion rate, relative to the experimental results was 0.0076%, implying over 99% model confidence level. The corrosion penetration depth on the mild steel per unit exposure time for experimental & model-predicted results were evaluated as: 4.406×10^{-4} mm and 4.509×10^{-4} mm, while corrosion rate per unit weight loss of the steel were 1.304 and 1.335mm/yr/g respectively. Evaluated correlations between corrosion rate and exposure time & weight loss of steel, as obtained from both results were all > 0.96. Deviational and statistical analyses of evaluated results indicate that the overall maximum discrepancy of model-predicted mild steel corrosion rate from experimental results was 2.4%.

Key words: Corrosion rate, mild steel, exposure time, weight loss, hibiscus sabdariffa leaf extract, sulphuric acid

INTRODUCTION

Mild steel has remained till date the most widely used ferrous alloy for a broad spectrum of applications. This is attributed to its weldability during construction of steel structures. Corrosion inhibition involves a process of suppressing or reducing corrosion. This has been adduced (Palou et al.2014, Evrim et al., 2016), to be the most economical and practical approach to reducing corrosion attack on metals and alloys. Very scintillating results [Evrim et al., 2016, Olawale et., 2015, Olawale., 2018a, Olawale et al., 2018b, Ita et al. 2016, Li et al., 2012, Li et al. 2014, Omotioma et al. 2017, Anadebe et al., 2018, Fouda et al. 2016, Udunwa et al, 2017, Chidiebere et al., 2016) have been generated by using various plant extracts for corrosion inhibition. Some of these plants includes; Bitter kola leaf, Ocimumgratissium, Gentiana olivieri, Cashew waste, Katemfe Bamboo, Pawpaw leaves and Thevetia Peruvianna, Delonixregia.

Studies (Moretti et al., 2004, Chidiebere et al., 2004) have shown that the adsorption strength of these inhibitors is dependent on certain significant factors. These includes: the nature and surface charge of the metal, structure of the inhibitor and composition of the electrolyte. Most effective inhibitors are organic compounds that contain heteroatoms like oxygen, sulphur and nitrogen in a conjugated system (De Sousa and Spinelli, 2009; Ebenso, 2001; Oguzie et al., 2005, Oguzie et al. 2014, Umoren et al., 2000, Oguzie, et al., 2009). Modification in the mechanism of the electrochemical process occurs when inhibitors interact with the metal surface through adsorption. These inhibitors function at the interface between the metal and aqueous corrosive solution. Report (Fontana, 1970) has shown that adsorption process is stabilized at the reaction centers regarded as polar functional groups. Based on the foregoing, corrosion susceptibility of the metal surface is reduced (Umoren et al., 2000, Chidiebere et al., 2015) and so the service life of the metal is prolonged.

Investigation (Chidiebere, 2016) has been carried out on the inhibition efficacy of aqueous extracts of the leaves of *Delonixregia* (DR) in 1 M HCland 0.5 M H_2SO_4. The study revealed that via adsorption of the extract organic matter on the metal/solution interface, DR extract inhibited mild steel corrosion in both acidicenvironments. Furthermore,Potentiodynamic polarization shows that DR is a mixed type inhibitor in both acidic environments, whereas the impedance results revealedadsorption of the DR species on a corroding steel surface. Also increase in inhibition efficiency wasdependent on concentration. The adsorption of DR followed Langmuir adsorption isotherm. A protective layer was formed and adsorbed on a mild steel surface in the acid solutions as indicated in the result of Scanning electronmicroscopy (SEM).

Chicken nails extract (CNE) has been successfully used for inhibiting mild steel corrosion in 2M H_2SO_4 (Olawale et al, 2019). The effect of some process parameters such as the inhibitor concentration (0.5–1.5g/l), time (5–8h) and temperature (40-70^{0}C) on inhibition efficiency were investigated using Response Surface Methodology. The Physiochemical analysis and proximate analysis of the CNE were also investigated. The result of the investigation revealed the presence of organic constituents which marked the Chicken-nails extract as an effective inhibitor. The inhibition efficiency increased as the inhibitor concentration increased while the rate of corrosion increases as time and temperature increased. The optimum conditions obtained were inhibitor concentration of 0.1 g/l, time 5 h and temperature 63.63^{0}C. The optimum Inhibition Efficiency at these optimum conditions was 74.04%. Result of Scanning Electron Microscopy revealed presence of passive layer of a film formed on the surface as a result of presence of the inhibitor. Onah et al. (2019) and Mbah et al. (2020) revealed the excellent inhibition of mild steel in 1.5 M HCl using Irvingia species.

Nwoye et al (2023) successfully derived an empirical model for predictive analysis of mild steel corrosion rate during the inhibitive activities of chicken-nail extract in 2M sulphuric acid. The range of process parameters used for reaction temperatures, corrosion rates, inhibitor concentrations and exposure times are 45- 70 (^{0}C), 1.216- 4.422 (mg /mm^2 h), 0.67-1.5 (g/l) and 5.5-8 (hrs) respectively. The mild steel corrosion rate was evaluated to be a direct function of the sum of the natural logarithms of reaction temperatures, inhibitor concentrations and exposure times. An empirical model;

$$\text{Ꞗ} = 1.3567 \ln \vartheta + 2.6196 \ln \beta + 3.1095 \ln \varepsilon - 13.49 \qquad (1)$$

predicts the corrosion rate with maximum deviation < 9.85% (from actual results), where Ꞗ = Corrosion rate of mild steel (mg/mm^2 h), ϑ = Concentration inhibitor (g/l), ε = Exposure time (hr) and β = Reaction temperature (^{0}C). The equalizing constants where exclusively resolved by the software; C-NIKBRAN to ensure that both sides of equation (1) are very close if not equal. It was therefore based on this that equation (1) was solved to get the unknown Ꞗ. This translated into over 91.15% operational confidence levels for the derived model. The validity of the model was rooted on the core model expression $\text{Ꞗ} + K = N \ln \vartheta + S \ln \beta + S_e \ln \varepsilon$ where both sides of the expression are correspondingly almost equal. The standard error incurred in predicting the model-based corrosion rate relative to values of the actual results is 0.2258. The correlation coefficients between corrosion rate and reaction temperature, inhibitor concentration and exposure time were all > 0.97.

A team of scientists (Nwoye et al., 2024) derived a model to evaluate the response of mild steel corrosion rate to the inhibitor (hypoxanthine) concentration and inhibition efficiency using a derived empirical model;

$$\xi = Ҽ\gamma^{-K} + ꞗ\eta^{-N} \qquad (2)$$

which is a sum of two parts, consisting two power expressions, where ξ, γ and η are the mild steel corrosion rate (g h^{-1} cm^{-2}), inhibitor concentration (mol dm^{-3}) and inhibition efficiency (%) respectively. The equalizing constants; Ҽ, K, ꞗ and N are 0.0001, 0.1066, 0.027 and 1.3721 respectively. They were generated using a software [9] In the course of the derivation, the range of values for the process parameters used were 2.46 $x10^{-4}$ - 2.98 x 10^{-4} (g $h^{-1}cm^{-2}$), 0.002-0.01(mol dm^{-3}) and 53.98- 61.94 (%) for corrosion rate, inhibitor concentrations and inhibition efficiencies respectively. The validity of the model is strongly rooted on the core model structure; $\xi – ꞗ\eta^{-N} \approx Ҽ\gamma^{-K}$. The model-predicted results agree with previous research on the inverse relationship between the corrosion rate and inhibitor concentration & inhibition efficiency. The standard error incurred in predicting the model-based corrosion rates relative to the actual results was < 0.04%, implying over 99% model confidence level. Corrosion rate per unit inhibitor concentration and inhibition efficiency were evaluated as - 0.0065 & - 0.00625 g h^{-1} cm^{-2} /mol dm^{-3} and - 6.53 x 10^{-6}& - 6.28 x 10^{-6} g h^{-1} cm^{-2} / %, using the actual and model-predicted results respectively. Furthermore, the correlations between these highlighted parameters, as evaluated from both results were all > 0.96. The overall maximum deviation of model-predicted corrosion rate from actual results was 5.62%.

Successful attempt was made to use Hibiscus Sadariffa (Agu, 2023) as a viable inhibitor to resists corrosion of mild steel in sulphuric acid solution. The active components of the inhibitor that militate against corrosion are anthocyanins, flavonoids, thiamine, niacin and tannins. These are powerful antioxidants with potential corrosion-inhibiting effects. Results of the investigation showed that the corrosion rate of mild steel in the sulphuric acid solution decreased and increased with the inhibitor concentration and exposure time respectively. Researches on existing models derived from corrosion studies indicate that no existing mathematical expression evaluates the corrosion rate of mild steel (submerged in sulphuric acid solution containing Hibiscus Sadariffa as inhibitor), relative to the exposure time and weight loss of the steel during the process, while the inhibitor concentration is constant. This therefore raised the need for the present work to bridge the knowledge gap.

The present work aims at mathematically deriving an empirical model that will evaluate or predict the response of mild steel corrosion rate in 0.5M H_2SO_4 to the synergistic influence of the mild steel exposure time and weight loss, in the course of the corrosion process. The inhibitor was chosen for this research due to its adsorptive properties on metal which enables it to form protective layers. It also exhibits mixed-inhibition behavior which reduces corrosion rates. The essence of this work is to derive a model that will reduce enormously the frequency of experimentals to evaluate the corrosion rate of mild steel in the highlighted solution while Hibiscus Sabdariffa acts as inhibitor. Based on the foregoing, the corrosion rate can simply be evaluated by substituting into the model values of exposure time and weight loss in any case, providing the boundary conditions of the process variables are the same.

2. Materials and methods

Gravimetric (weight loss) approach was used to evaluate the inhibition performance of HS in the acidic medium; 0.5M, H_2SO_4

2.1 Gravimetric Analysis

The gravimetric (weight loss) method is the most widely method of corrosion inhibition assessment (Musa et al.,2010). In this study, the mild steel coupons were mechanically press-cut into dimensions of 40mm×30mm×20mm with a hole 1.5mm diameter at the top centre of the coupon. They were cleaned with energy paper of increasing mesh size until mirror surface and kept in a desicator. The leaves of Hibiscus Sabdariffa were sun-dried and a mass of 200g was soaked in one litre of ethanol for 48hrs. The filtrate (containing inhibitor and ethanol) was decanted into an open conical flask and the residue, after squeezing out the liquid, was discarded. The filtrate was allowed open with slight heating for ethanol to evaporate at 78°C. The 0.5m H_2SO_4 .The weighing was done with the 4-digit HAUS electronic weighing machine. Corrosion rate, expressed in mm/yr, was determined by

$$\xi = \frac{k\,\Delta W}{\rho A\, t} \qquad (3)$$

Where,

A = Exposed surface area; $2(LB+LT+BT) - 2(\pi d^2/4) + \pi dT$ (mm^2)

L, B, T and D are length, breadth, thickness and diameter (mm) respectively

ρ = Density of the mild steel ($7.85 g/cm^2$)

$t = \theta$; Exposure time (year)

k = constant; 8.76×10^4 (for corrosion rate in mm/yr)

ΔW = Weight loss following corrosion (g)

The efficiency of the inhibitor (%) used was evaluated using the expression;

$$\eta = \left(\frac{C_a - C_i}{C_a} \right) x\ 100\ \% \qquad (4)$$

Corrosion penetration depth δ (mm) is calculated using the expression;

$$\delta = \theta\, C_i \qquad (5)$$

Where,

C_a = Corrosion rate in absence of inhibitor (mm/yr)

C_i = Corrosion rate in presence of inhibitor (mm/yr)

Table 1: Variation of mild steel corrosion rate with exposure time and weight loss of steel at constant inhibitor concentration (10mls) (Agu,2023)

(τ)	(τ)	(ξ)	(ɤ)	(γ)
48	0.00548	0.6916	0.0799	10.0
60	0.00685	0.7376	0.1079	10.0
72	0.00822	0.7836	0.1358	10.0
84	0.00959	0.7988	0.1621	10.0
108	0.01230	0.7841	0.2030	10.0
120	0.01370	0.7541	0.2178	10.0
132	0.01510	0.7314	0.2317	10.0
144	0.01640	0.7086	0.2456	10.0

Model Formulation

Computational analysis of the experimental results shown in Table 1, resulted to Table 2 which indicate that;

$$\left(\frac{\xi}{\text{ꞗ}}\right) - \text{Ǧ} \approx - \text{ß}\text{ɤ}^2 + \text{Ҽ}\text{ɤ} - \text{N}\tau^2 + \Phi\tau \qquad (6)$$

$$\frac{\xi}{\text{ꞗ}} = - \text{ß}\text{ɤ}^2 + \text{Ҽ}\text{ɤ} - \text{N}\tau^2 + \Phi\tau + \text{Ǧ} \qquad (7)$$

$$\xi = \text{ꞗ}\,(- \text{ß}\text{ɤ}^2 + \text{Ҽ}\text{ɤ} - \text{N}\tau^2 + \Phi\tau + \text{Ǧ}) \qquad (8)$$

For Simplicity

$$\xi = \text{ꞗ}\text{K} \qquad (9)$$

Where $\text{K} = (- \text{ß}\text{ɤ}^2 + \text{Ҽ}\text{ɤ} - \text{N}\tau^2 + \Phi\tau + \text{Ǧ})$

Equation (8) is the derived empirical model which evaluates the mild steel corrosion rate at known values of the exposure time and weight loss of the steel (even under protection by inhibitor) while submerged in H_2SO_4. The variables ξ, τ and ɤ are the corrosion rate (mm/yr), exposure time (yr) and weight loss of steel (during corrosion) g respectively. The equalizing constants; ꞗ, Ǧ, ß, Ҽ, N and Φ are 38.4958, 0.00976, 0.2053, 0.0682, 45.5881 and 1.0 respectively. The constants were generated using a software (Nwoye, 2025). The software mapped the experimental data, creates the core model structure on which the validity of the model is rooted. It generated the constants which equalize both sides of the core model structure in terms of units and magnitude.

4. Results and Discussion

4.1 Boundary and Initial Conditions

Consider mild steel, interacting with sulphuric acid in the presence of sabdariffa (inhibitor). As a result of the interaction, the steel lost weight following corrosion. Corrosion of the mild steel was determined by the roles played by the sulphuric acid and inhibitor. The extents of the roles by these aqueous solutions were in turn dependent of their various concentrations and the time within which the mild steel was exposed to the highlighted interaction. During the model derivation, the considered ranges of exposure time, weight loss and corrosion rate were 0.00548 – 0.0164 yr, 0.0799 – 0.2456g, 0.6916 - 0.7086mm/yr respectively. The concentration of the inhibitor γ used in generating values in Table 1 was 10mls.

Table 2: Variation of (ξ/Ђ) - Ǧ with - ßɤ^2 + Ꝋɤ - Nτ^2 + Φτ

(ξ/Ђ) – Ǧ	- ßɤ^2 + Ꝋɤ - Nτ^2 + Φτ	Differential
0.00821	0.00825	-0.00004
0.00940	0.00968	-0.00028
0.01060	0.01061	-0.00001
0.01100	0.01110	-0.00001
0.01060	0.01078	-0.00018
0.00983	0.01030	-0.00047
0.00924	0.00950	-0.00026
0.00865	0.00851	-0.00015

Table 1 shows the variation of corrosion rate with exposure time and mild steel weight loss during the corrosion process. The core model structure expressed in (1) is the basis on which the validity of the model in (8) is rooted. This is stemmed on the fact that the evaluated structure components at both sides of the structure as shown in Table 2 are correspondingly almost equal. The negligible differentials in each line of Table 2 show that both sides of the model components are correspondingly almost equal. This is an indication that any subject of the formular using equation (8) will give values with very admissible deviation.

4.2 Model Validity

The derived model was also validated by comparing the predicted results with the experimental, through graphical, statistical and deviational analysis.

4.2.1 Graphical Analysis

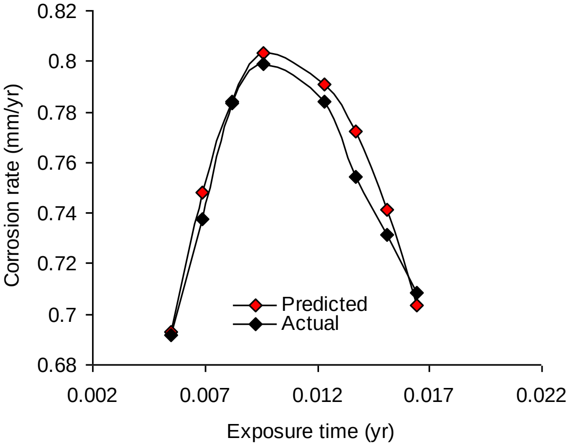

Fig. 1 Variation of corrosion rate with exposure time as obtainedfrom experiment and model prediction

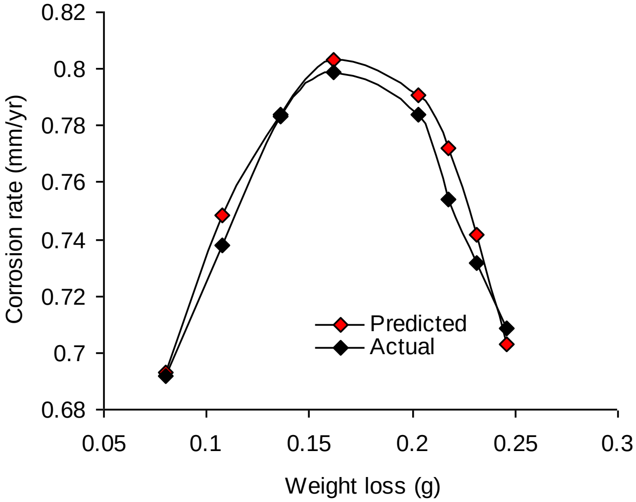

Fig. 2 Variation of corrosion rate with weight loss as obtainedfrom experiment and model prediction

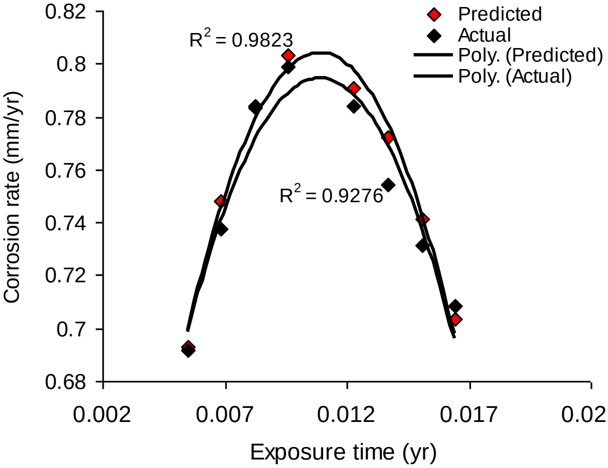

Figure 3: Comparison of mild steel corrosion rates (relative to exposure times) as evaluated from experimental results and derived model

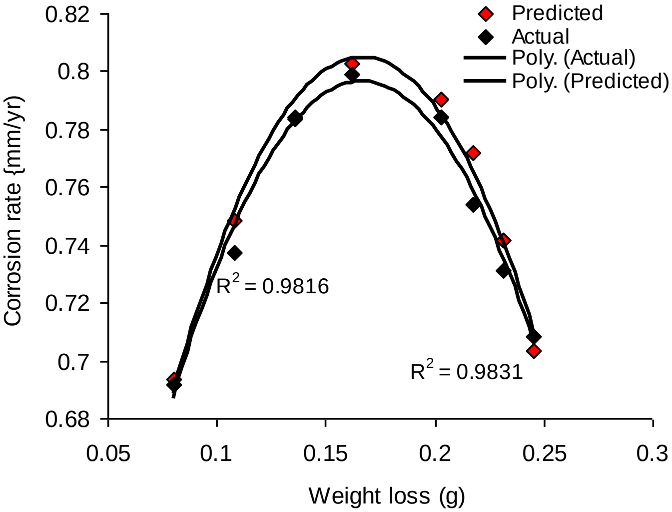

Figure 4: Comparison of mild steel corrosion rates (relative to weight loss) as evaluated from experimental results and derived model

Graphical presentations in Figs. 1 & 2 and Figs. 3 & 4 are same in all ramifications except that the later shows the correlations (on evaluating R^2) between the corrosion rate and exposure time & mild steel weight loss. These correlations indicate the level of responses picked by corrosion rate following interactive inputs from exposure time as well as steel weight loss during the corrosion process.

These figures are characterized by similar trend and spread of results point. The corrosion rate-exposure time and corrosion rate – weight loss plots show a rise to maximum value in each case, followed by decrease. This suggests that after 84 hrs (0.00959 yr) the mild steel corrosion rate began to decrease possible due to formation of passive oxide film on the steel surface, which resisted further corrosion.

A plot of the model predicted corrosion rate against (- ßɤ^2 + Ҽɤ - Nτ^2 + Φτ+ Ǧ) denoted by Kgives a straight line with a slope S; 38.4615. This agrees with the empirical constant Ꜧ generated as 38.4958 by EmpericL AB in equation (6), to equalize both sides of the core model structure. It is pertinent to note that the coefficient of determination R^2 between the corrosion rate and K is 0.9985. This translated to the level of alignment of the points on the line, indicating slope precision and admissibility of the derived model. The model has chemical significance because corrosion of the steel is an irreversible chemical change in the metal. And so the model predicts the extent of this irreversible change (corrosion rate), relative to the weight of metal loss (due to corrosion) and time of exposure of the metal. Based on the foregoing, the graphical representation depicting a good curve fitting is a mirror-image of the trend of the chemical change translated into lines.

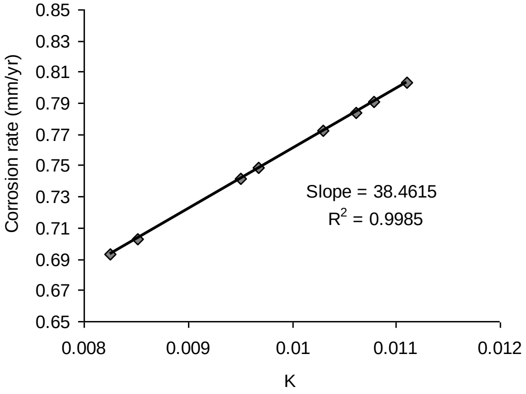

Figure 5: Variation of mild steel corrosion rate expression (- ßɤ^2 + Ҽɤ - Nτ^2 + Φτ+ Ǧ)

4.2.2 StatisticalAnalysis

The evaluated correlations from the coefficients of determination R^2 shown in Figure 3 and Figure 4, between corrosion rate and exposure time & weight loss (using Microsoft Excel version 2003) are 0.9631 and 0.9911 & 0.9908 and 0.9915, using experimental results and model predictions respectively. Comparative analyses of these correlations indicate a better line fittedness with mild steel weight loss. This shows that steel weight loss was a higher determinant of the magnitude of corrosion on the metal, eventhough the weight loss is dependent on exposure time of the steel. The correlations were calculated using the relationship

$$R = \sqrt{R^2} \qquad (10)$$

Statistical analysis of generated results indicate that for every change in the exposure time and steel weight loss, the overall standard error incurred (as evaluated using Microsoft Excel version 2003) on predicting the mild steel corrosion rate relative to experimental results is 0.0076%. This gives a model confidence level above 99.9%.

Table 3: Differential between experimentally determined andmodel-predicted mild steel corrosion rates

(γ)	$\Delta\xi = \xi_M - \xi_\varepsilon$
0.0799	0.0017
0.1079	0.0108
0.1358	0.0006
0.1621	0.0042
0.2030	0.0066
0.2178	0.0181
0.2317	0.0100
0.2456	-0.0053

Table 3 outlines negligible differentials between experimentally determined and corresponding model-predicted exposure times. This shows to a significant level that the derived model is functional and admissible. The table also shows that these differentials have positive and negative values, relative to the corresponding experimental results. This indicates increased and decreased model-predicted values respectively.

4.2.3 Deviational Analysis

Analysis of corrosion rate as obtained from actual and derived model show deviation of model-predicted values from those of the actual. This is believed to be due to the fact that some considered assumptions and experiment-oriented conditions which prevailed during the actual field work were not considered during the model formulation. This necessitated the introduction of correction factor, to bring the model-predicted values to those of the actual.

Deviation (Dv) (%) of the model-predicted corrosion rate from that of the experimental is given by

$$Dv = \left(\frac{\xi_m - \xi_E}{\xi_a}\right) \text{ x } 100 \tag{11}$$

Where

ξ_m = Model-predicted corrosion rate
ξ_a = Corrosion rate evaluated from experimental results

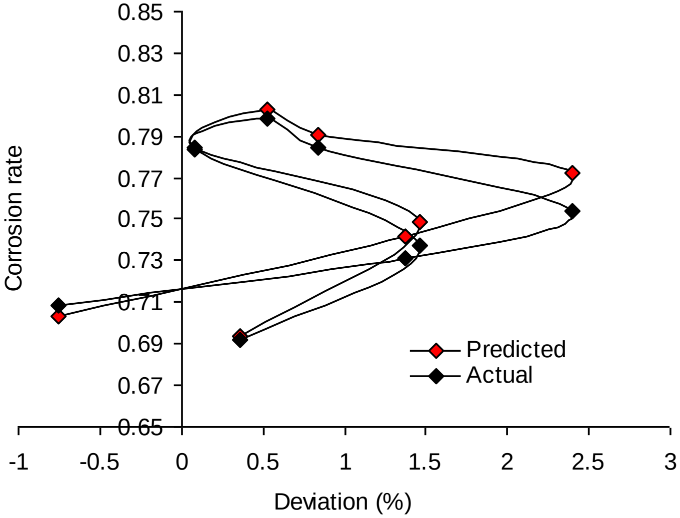

Figure 7: Variation of model-predicted corrosion rate with its corresponding deviation from experimental results

Figure 7 indicates that the overall maximum deviation of model-predicted ξ is 2.4%. This gives operational model confidence levels above 97%. The figure also shows that the least and highest magnitude of deviations of the model-predicted ξ is 0.08 and 2.4% respectively. These highlighted deviations correspond to the corrosion rates: 0.7836 & 0.7541 mm/yr, exposure times: 0.00822 & 0.0137 yr and weight losses: 0.1358 & 0.2178g respectively. Based on the foregoing, the overall model confidence level places between 97 and 99%.

The deviation of model predicted results from that of the experimental is just the magnitude of the value. The associated sign preceding the value signifies that the deviation is deficit (negative sign) or surplus (positive sign).

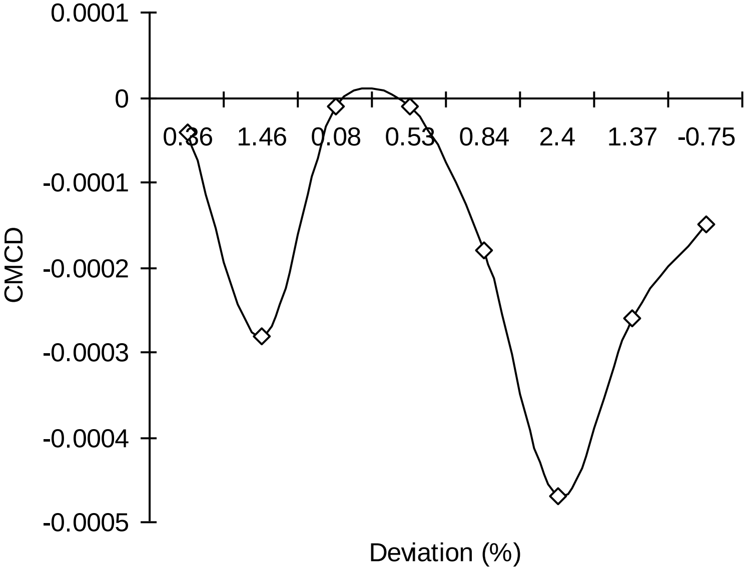

Figure 8: Variation of Core Model Component Differentials (CMCD)with deviation of model predicted corrosion rates

Figure 8 shows the plot of the CMCD against the deviation of model predicted corrosion rates. Graphical analysis of the curve shows that as the differential between both components of the core model structureincreases in magnitude, the model deviation from experimental values increases. This goes to confirm that the core model structure is the basis on which the validity of the derived empirical model is hinged.

Correction factor (Cr) is the negative of the deviation i.e

$$Cr = -Dv \qquad (12)$$

Therefore

$$Cr = -100\left(\frac{\xi_m - \xi_a}{\xi_a}\right) \qquad (13)$$

Introduction of the corresponding values of Cf from equation (12) into the model gives exactly the corresponding experimental values. Equations (11) and (12) show that correction factor is the negative of the deviation. It is strongly believed that the correction factor takes care of the assumptions made and experimental condition prevailing during the field works which were not considered during the model formulation. Corrosion penetration depth (on the mild steel) per unit exposure time $\mathcal{E}$ ($\xi\,\tau$) (mm) was calculated from the expression;

$$\mathcal{E} = \xi\,\tau \qquad (14)$$

Re-written as

$$\mathcal{E} = \Delta\xi\Delta\tau \qquad (15)$$

The expression (13), is detailed as

$$\mathcal{E} = \xi_2 - \xi_1\,(\tau_2 - \tau_1) \qquad (16)$$

Where

$\Delta\xi$ = Change in the mild steel corrosion rates ξ_2, ξ_1 at two exposure times τ_2, τ_1

Considering points (0.00548, 0.6916) & (0.00959, 0.7988) and (0.00548, 0.6933) & (0.00959, 0.803) during increasing corrosion rate as shown in Figure 1, designated as (ξ_1, δ_1) and (ξ_2, δ_2) for experimental and model-predicted results, and then substituted into the expression (16), gives the slope: 4.406 x 10^{-4} mm and 4.509 x 10^{-4} mm, as their respective corrosion penetration depth per unit exposure time. Corrosion rate of mild steel per unit weight loss of the steel □ (ξ /ɤ) (mm/yr/g) was calculated from the expression;

$$\square = \xi / \text{ɤ} \qquad (17)$$

Re-written as

$$\square = \Delta\xi / \Delta\text{ɤ}$$

(18)

The expression (18), is detailed as

$$\square = \xi_2 - \xi_1 / ɤ_2 - ɤ_1 \quad (19)$$

Where

$\Delta ɤ$ = Change in the mild steel weight losses $ɤ_2$, $ɤ_1$

On considering points (0.0799, 0.6916) & (0.1621, 0.7899) and (0.0799, 0.6933) & (0.1621, 0.803) during increasing corrosion rate as shown in Figure 2, and designating them as (ξ_1, $ɤ_1$) and (ξ_2, $ɤ_2$) for experimental and model-predicted results, and then substituting them into the expression (19), gives the slopes: 1.304 and 1.335mm/yr/g, as their respective corrosion rate per unit weight loss of mild steel.

5. Conclusion

The response of mild steel corrosion rate in 0.5M H_2SO_4 (while in contact with an indicator-Hibiscus Sabdriffa) to the synergistic influence of exposure time and weight loss of the steel was has been successfully evaluated. The predictive evaluation was carried out using a derived empirical model; $\xi = Ꜧ(- ßɤ^2 + Ꝋɤ - N\tau^2 + \Phi\tau + \check{G})$. The validity of the derived model is strongly rooted on the core model structure; $(\xi/Ꜧ) - \check{G} \approx - ßɤ^2 + Ꝋɤ - N\tau^2 + \Phi\tau$.. The model-predicted results showed a polynomial relationship between the corrosion rate and exposure time & mild steel weight loss (while inhibitor concentration is constant); in agree with previous research. The standard error associating model prediction of corrosion rate, relative to the experimental results was 0.0076%, implying over 99% model confidence level. The corrosion penetration depth on the mild steel per unit exposure time for experimental & model-predicted results were evaluated as: 4.406×10^{-4} mm and 4.509×10^{-4} mm, while corrosion rate per unit weight loss of the steel were 1.304 and 1.335mm/yr/g respectively. Evaluated correlations between corrosion rate and exposure time & weight loss of steel, as obtained from both results were all > 0.96. The overall maximum deviation of model-predicted mild steel corrosion rate from experimental results was 2.4%.

The limitations of the derived model is that it can only be applied to corrosion processes involving mild steel exposure in sulphur acid containing Hibiscus sabdariffa as inhibitor. Furthermore, the mild steel corrosion rate cannot be predicted beyond the boundary conditions stated in the range of process parameters applied, except through simulation. The model can find application in industries where mild steel pipelines or other structures are exposed to sulphur acid during service. The usefulness of the model in the industries will abound, through simulations to bring in other variables and also extend the boundary conditions already worked on.

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