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Research Article

Synergistic Inhibition of Mild Steel Corrosion in Seawater and Acidic Medium by Cathodic Protection and *Monodora myristica* Using Zinc Anode

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The synergistic inhibition of mild steel corrosion in seawater and 0.1M sulphuric acid by the cathodic protection and *Monodora myristica* was carried out through the weight loss and the linear polarization resistance (LPR) measurement. The results showed that in seawater, the synergism was not too effective for the protection of steel, whereas in 0.1M sulphuric acid, there was a great synergism between cathodic protection and the oil extracts of *Monodora myristica*, having an efficiency (IE%) of 102.89% at 15 mL of the oil extracts. For the linear polarization resistance (LPR), in most of the cases, there was a slight shift of the corrosion potential (E_{corr}) and the open circuit potential (OPC) toward the positive as the volume of the oil extracts increased, thereby causing a change in the cathodic and the anodic Tafel slopes, which showed that the inhibitor is a mixed- type inhibitor. The corrosion current density (icorr) decreases as the volumes of the oil extract increase. Langmuir adsorption isotherm fitted best with an R^2 of 1 unit, indicating a good agreement with the experimental data and with Langmuir adsorption isotherm.

1. Introduction

Corrosion is a phenomenon that occurs naturally in our environment. It is a process that alters a processed metal into a chemically stable form, such as its oxides, hydroxide, and sulphide [1]. All metal surfaces, excluding gold, are protected with oxide films when exposed to the atmosphere. This oxide film on the metal surface tends to disband when immersed in an aqueous solution. However, if the solution is acidic, the oxide film may dissolve completely leaving an unprotected metal surface, which is said to be in the active state [2]. In near solution, the solubility of an oxide on the surface of a metal will be reduced than in acid solution, while the degree of dissolution will tend to be smaller. The study of the soil corrosion of buried-structural materials is important because millions of miles of the buried steels or iron pipeline are used to supply the drinking water, gas, oil, and so on in the world. Many buried-structural materials, such as galvanized water supply pipelines, natural gas, and crude oil pipelines have been corroded by soils all around the world [3–9]. The study on Nigeria pipeline of crude oil (along the Obrikom-Ebocha areas) showed that the oil resistivity value decreased with increasing the moisture content and temperature [8]. The corrosion rate of the buried-structural materials is mainly influenced by six different soil parameters, namely, moisture content, pH, resistivity, oxidation-reduction potential, chloride, and sulfate contents [10–12]. The corrosion rate of most structures produced from mild steel (e.g., ships, tankers, reservoirs, storage tanks, and offshore platforms) used in aqueous media (e.g., seawater, oil, and soil) depends on the aqueous solution compositions and different environmental conditions such as concentration of Cl^-, SO_4^{2-}, S^{2-}, O_2, pH, and temperature [10–12]. Hence, corrosion protection systems must be reliable and efficient. Several compounds of inhibitors are known for these purposes [13–15]. Amongst the several methods available in preventing or controlling corrosion is the cathodic protection technique. This technique developed by Sir Humphrey Davy in 1824 was explained for the first time in a sequence of works offered to the Royal Society in London [16]. Cathodic protection is a method

utilized to lessen the effect of rusting by decreasing the difference in potential between the anode and cathode. It is accomplished by applying a current to the structure to be secured (such as a pipeline) from some external source. When adequate current is applied, the entire structure will function as one potential; hence, the anode and cathode positions will cease to exist. Many different types of structure utilize this common technique. For example, it is used for pipeline, locks, underground storage tanks, and ship hulls protection [17]. The theory behind it is to supply enough electrons to the anodic area so that it becomes cathodic, thus slowing down or eliminating the anode altogether. This is done through the use of an external anodic material that supplements the supply of electrons to the area in danger [16]. It can also function by transforming undesirable anodic (active) sites on a metal's surface to cathodic (passive) sites via the use of an opposing current. This opposing current supply free electrons and forces local anodes to be polarized to the potential of the local cathodes [18]. Cathodic protection is more reliable, effective, and economical method for protection of a variety of pipelines, tanks, and marine structures including ships hulls and submarines against corrosion. Cathodic protection works primarily by depressing the natural corrosion potential of the structure to be protected to a value where it does not corrode [19, 20]. Coating, alongside with cathodic protection can be used together. Both of them complement each other where possible, such that one can use them in combination to achieve the optimal economy and protection. The coating protects everywhere but at holidays. This combination minimizes the amount of current a cathodic protection system must provide and distributes that current further and more evenly. With undercutting of the coating by corrosion mitigated, a coating can last longer [21]. However, the coating system must be compatible with cathodic protection and the level of cathodic protection must not be excessive. Though, normally, compatible coatings may break up due to excessive levels of cathodic protection. This gives way for corrosion to take place at the disbandment area, where cathodic protection currents may not be able to reach. Several works have been carried out by researchers on the inhibition of mild steel using synergism of different inhibitors [22–24]. Frunjo Ivusic et al. [22] discussed the synergistic inhibition of mild steel corrosion in seawater by cerium chloride and sodium gluconate. Roya Farahmand et al. [23] described the synergistic effect of molybdenum coating and SDS surfactant on corrosion inhibition of mild steel in the presence of 3.5% NaCl. Although the synergism of cathodic protection and plant extract inhibitors are not that common, some works have been done with them. Efim Ya Layublinski [24] worked on the synergism in corrosion protection system with inhibitors. Panpan et al. [25] investigated the corrosion inhibition performance of X70 pipeline steel in seawater using carboxymethyl chitosan (CMCS) and Na_2WO_4 at a cathodic protection potential of -0.85v (versus SCE). It was observed that, as corrosion inhibitors, CMCS and Na_2WO_4 show a brilliant synergy for the protection of X70 pipeline steel in seawater. According to Adewole et al. [26], the phytochemical antimicrobial and GC-MS of African Nutmeg (*Monodora myristica*) were analyzed for the phytochemical components of *Monodora myristica*. From this study, it was observed that it contains some organic compounds which have good potential for corrosion inhibition studies. Such compounds include alkaloid (12.62%), saponin (2.273 mg/g ± 0.01), tannin (0.002 mg/g ± 0.002), and flavonoid (0.541 mg/g ± 0.001).

The present study is aimed at investigating the synergistic effect of *Monodora myristica* (African Nutmeg) oil extract and cathodic protection on the corrosion inhibition of mild steel in seawater and 0.1M sulphuric acid solution using zinc sacrificial anode.

2. Materials and Methods

2.1. Samples Collection. All the samples used for this experiment were sourced locally. The seeds of *Monodora myristic*a (African Nutmeg) used were bought from Oja Ota market in Ota, Ogun State, while the mild steel was brought from the mild steel dealer in Ota, Ogun State. Seawater was collected from Elegushi beach in Lekki-Ajah, Lagos State.

2.2. Preparation of 0.1M Sulphuric Acid. 5.33 ml of concentrated sulphuric acid (assay 98% and density 1.8) was measured in a 1-liter standard flask and distilled water was added to make up the mark. The solution was standardized with a standard solution of sodium carbonate (Na_2CO_3).

2.3. Preparation of Monodora myristica Extract. The *Monodora myristic*a fruits were broken so as to free the seed inside, and then the seeds collected were dried in hot air oven at 80°C temperature, till all the water content is evaporated. After that, the sample was weighed using a weighing balance, and the total weight of the sample was 1006.456 g. To improvise, filter papers (180 mm) were used to wrap the sample and tied with threads before inserted into the Soxhlet extractors for refluxing. The solvent used for the extraction was N-Hexane at a temperature of 60°C for several hours till all the extracts were collected. But, the solution containing the extract was evaporated using the rotary evaporator to evaporate all the solvent (N-Hexane) from it. The oil was recovered as the extract and the volume of the oil extracted was 422.273ml. The oil was stored in an amber bottle and kept in a cool dry place.

2.4. Metal Preparation. The mild steel used for this study has a chemical composition as shown in Tables 1 and 2.

The mild steel was mechanically machined using a vice with a hacksaw and cut into coupons (50 pieces) of dimension (3 cm × 3 cm × 0.2 cm), while the one used for polarization measurement has dimension 0.1 cm × 0.1 cm. These coupons were all polished with series of emery papers up to 800 grits sizes starting from the coarsest to the finest grit size. The zinc sacrificial anodes were used. They were also cut into shape before use. The polished coupons were degreased with ethanol and allowed to dry before weighing them.

2.5. Weight Loss Measurement. The weight losses for this study were carried out by measuring 400 mL of seawater and

Table 1: Chemical components of mild steel.

Elements	Si	Fe	Cu	Mn	Pb	Cr	Ni	Al	P	C	S	Co	V
% present	0.018	99.36	0.034	0.189	0.006	0.025	0.031	0.052	0.013	0.142	0.012	0.045	0.016

Table 2: Chemical composition of zinc.

Elements	Zn	Cu	Pb	Fe	Ti	Cd	Al	Sn
% present	99.8	0.07	0.04	0.01	<0.03	0.01	0.01	0.003

500 mL of 0.1M H_2SO_4 acids, respectively, into a plastic cup and, then, the mild steel was subjected to the media. For the cathodic protection test, the galvanic (sacrificial) method of protection system was employed, where the zinc sacrificial anodes were used and a copper wire serves as a conductor between the metal and the anode with a rod used as support. These samples were weighed before and after retrieval from the corrodent using an analytical balance. The weight losses were all monitored at 3-day interval for the period of 21 days of exposure. After the reading, the metal's weight loss or gain (W_L), corrosion rate (W), inhibition efficiency (%), and surface coverage were calculated using the formulas given below:

$$w_L = w_i - w_f \quad (1)$$

$$CR = \frac{143.700 \times w_L}{7.85 \times A \times T} \quad (2)$$

$$I.E\,(\%) = \frac{\Delta w_o - \Delta w_{inh}}{\Delta w_o} \times 100 \quad (3)$$

where W_L is the difference between the initial weight and the final weight of the mild steel metals. And, W_i and W_f are the values for the weight loss of the steel without and with the addition of inhibitors in the solution, respectively. C_R is the corrosion rate of the mild steel, A is the surface area of the steel, and T is the time of immersion. The value 7.85 is the density of the mild steel, while 143,700 is the constant used for calculating corrosion rate in Mpy, coupon area (cm^2). ΔW_0 is the change in weight without the inhibitor and ΔW_{inh} is the change in weight with the inhibitor.

However, the surface coverage is a function of the degree of coverage of the metal surface by the inhibitor molecules. Mathematically, it is represented as

$$\theta = \frac{\Delta w_o - \Delta w_{inh}}{\Delta w_o} \quad (4)$$

where θ is the surface coverage.

2.6. Electrochemical Test. The linear polarization resistance (LPR) analysis test was carried out using the Autolab potentiostat-galvanometer Nova 2.1.1 system at normal room temperature. The Linear polarization resistance (LPR) consists of three-electrode system, which includes the saturated calomel reference electrode (SCE) and the working and the counterelectrode. The SCE is the reference electrode, and the working electrode is the mild steel with an exposed area of $1cm^2$ for each metal. The sacrificial electrode acted as counterelectrode. Prior to the measurement, 100 mL of the corrodent (seawater/0.1M acid) was measured into a beaker before the working electrode was dipped into seawater and 0.1M sulphuric acid containing different volumes of *Monodora myristica* oil extracts for 15mins until a stable open circuit potential (OCP) was obtained. The OCP values started from -0.1mv and stopped at +0.1mv at a scan rate of 0.001 mv. The values obtained for different parameters during the Tafel plots are shown in Tables 4 and 5.

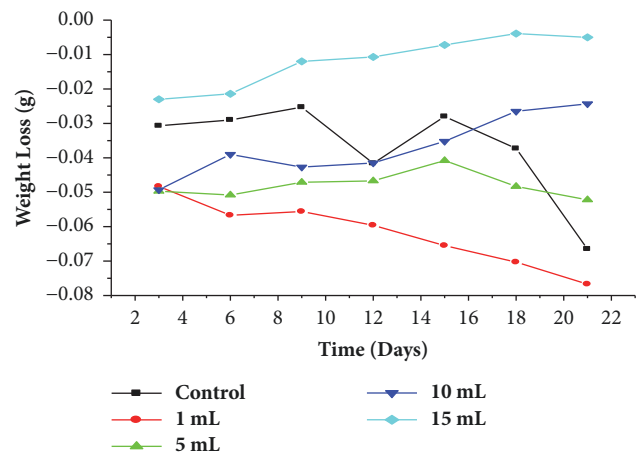

Figure 1: Variation of weight loss against time for the cathodic protection and oil extract for steel with zinc in different volumes of oil extracts in seawater.

3. Results and Discussion

3.1. Weight Loss Measurement. The plot for the synergistic effect of cathodic protection and different volumes of *Monodora myristica* oil extract for steel with zinc anode in seawater is shown in Figure 1. It is observed from the plot that the weight loss for the cathodic protection and oil extract for steel with zinc anode decreased with respect to time for free-inhibitor (control), 1 mL and 5 mL oil extracts, respectively, as seen in Figure 1, but for other higher volumes of oil extracts, 10 mL and 15 mL, the weight loss increases with time. This trend is contrary to the expected outcome of an increase in the weight loss of mild steel during the active period of mild steel. However, the decrease in weight loss against time as shown in Figure 1 was a result of the increase in the initial weight of the mild steel. The increase in the initial weight of the mild steel could be a result of possible deposits like

Table 3: pH values for cathodic protection and different volumes of oil extract for steel with zinc in seawater.

Days	Control	1 mL	5 mL	10 mL	15 mL
0	7.51	7.56	6.96	6.70	6.52
3	7.60	6.95	6.85	6.72	6.65
6	7.57	7.05	6.85	6.28	6.11
9	7.75	7.37	7.08	6.64	6.26
12	7.31	7.26	6.95	6.84	6.40
15	7.45	7.20	7.05	6.92	6.75
18	7.59	7.31	7.17	6.78	6.64
21	7.40	6.80	6.65	6.52	6.45

Table 4: Electrochemical parameters obtained from the Tafel plots for cathodic protection and different volumes (ml) of oil extract of *Monodora myristica* for steel with zinc in seawater environment.

Extracts Vol (ml)	OCP (V)	$E_{corr.}$ Obs (V)	B_c (V/dec)	B_a (V/dec)	icorr ($A/cm^2 * 10^{-5}$)	Polarization Resistance (Ω)	I.E (%)
Control	-0.517	-0.503	0.003	0.003	2.2449E-08	31238	-
1	-0.587	-0.604	0.002	0.003	9.1358E-08	5664	-306.95
5	-0.465	-0.453	0.002	0.002	1.0141E-08	42661	54.8
10	-0.489	-0.475	0.002	0.002	4.9065E-09	91520	78
15	-0.620	-0.625	0.001	0.002	4.7488E-09	83378	78.8

Table 5: Electrochemical parameters obtained from the Tafel plots for cathodic protection and different volumes (ml) of oil extract of *Monodora myristica* for steel with zinc in 0.1M sulphuric acid.

Extracts Vol (ml)	OCP (V)	$E_{corr.}$ Obs (V)	Bc (V/dec)	B_a (V/dec)	icorr ($A/cm^2 * 10^{-5}$)	Polarization Resistance (Ω)	I.E (%)
Control	-0.532	-0.540	0.004	0.005	1.7982E-05	52.847	-
1	-0.488	-0.484	0.003	0.002	5.4309E-07	849.87	96.97
5	-0.516	-0.509	0.003	0.002	1.7283E-07	2722.8	99
10	-0.494	-0.482	0.001	0.003	1.4303E-08	27040	99.99
15	-0.344	-0.392	0.005	0.009	1.0058E-10	1.3271E+07	99.99

$CaCO_3$ and $Mg(OH)_2$ on the surface of the steel, that is, a reaction between a mild steel's surface and some components of seawater.

According to Li and Du, [27], calcareous deposits will form on the protected steel surface after cathodic protection in seawater. This is due to hydrogen evolution and oxygen reduction reactions.

$$H_2O + \frac{1}{2}O_2 + 2e^- \longrightarrow 2OH^- \quad (5)$$

$$2H_2O + 2e^- \longrightarrow 2OH^- + H_2 \quad (6)$$

Due to the production of OH^-, the magnesium ions will react with OH^- and are deposited as brucite of $Mg(OH)_2$ on the steel surface. Furthermore, with the change in pH near the steel surface, the inorganic carbonic equilibrium will be upset, leading to the concentration of carbonate ions and the precipitation of $CaCO_3$.

$$Mg^{2+} + 2OH^- \longrightarrow Mg(OH)_2 \quad (7)$$

$$Ca^{2+} + CO_3 \longrightarrow CaCO_3 \quad (8)$$

As these nonconductive deposits progressively cover the surface, the flux of dissolved oxygen from seawater toward the steel surface is limited. In addition, the overall rate of the cathodic protection reaction (4) decreases, leading to a reduction in the cathodic current density required and the consumption of the sacrificial anode [28–32]. But, however, according to Corrosionpedia [33], a calcareous deposit is a layer that consists of calcium carbonate and other salts deposited on the substrate's surface. When the surface is cathodically polarized, as in cathodic protection, this layer is the result of the increased pH adjacent to the protection surface. Thus, from Table 3, it showed the pH values for the cathodic protection and different volumes of oil extracts for steel with zinc. From this table, it is observed that the pH values decreased as the volumes of the oil extract increased. This suggests that, as the pH of the electrolyte decreased, there was a corresponding increase in the acidity or H^+ ion concentration of the solution. This is presumed to have prompted the dissolution of the calcareous deposit previously observed on the surface of the steel. Consequently, this situation exposes the cathodic protection system to the solution, thereby activating the oxidization reaction of the anode which on the other hand caused the increase in the weight loss as observed with the 10 mL and 15 mL of the oil extract seen in Figure 1. This is the reason cathodic protection and oil extracts for steel with zinc are not very effective in the prevention of steel in a seawater environment.

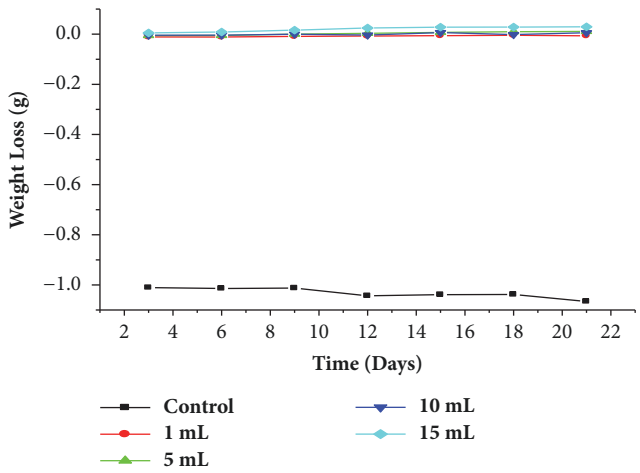

Figure 2: Variation of weight loss against time for the cathodic protection and oil extract for steel with zinc in different volumes of oil extracts in 0.1M sulphuric acid.

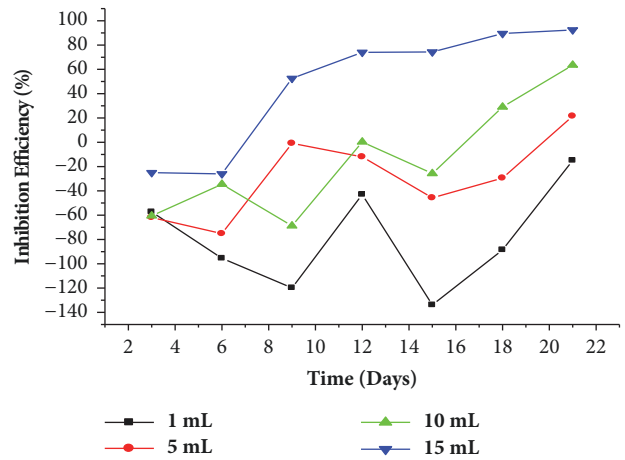

Figure 3: Variation of inhibition efficiency against time for the cathodic protection and different volumes of oil extracts for steel with zinc in seawater.

For the cathodic protection of steel with zinc in 0.1M sulphuric acid, between the free-inhibitor (control) and the 15 mL oil extracts, very slight increases in the weight loss were observed, though in the negative range. The weight loss ranges from -1.0 in free-inhibitor to 0.00 in 15 mL oil extracts as shown in Figure 2. The cathodic protection and oil extract for steel with zinc in 0.1M sulphuric acid suggest the compatibility of the sacrificial anode (Zn) and the oil extract of *Monodora myristica*. It showed that, in 0.1M sulphuric acid, the cathodic protection and oil extract of steel with zinc inhibit completely the degradation of steel. It indicated that the synergism of cathodic protection and oil extract for steel with zinc inhibited both the anodic and the cathodic side of the reaction, forcing the weight to remain at zero. This means that more electrons were released in addition to the oil extract, helping to protect the mild steel by stopping completely both the oxidation and oxygen reduction reaction of steel.

Comparing the above observations in 0.1M sulphuric acid and seawater, it is very clear from all the plots that the synergistic effect of cathodic protection and oil extract of *Monodora myristica* for steel with zinc proves to be the best corrosion prevention method compared to the cathodic protection and oil extracts of steel with zinc in a seawater environment.

For the inhibition efficiency (IE %) for the synergistic cathodic protection and oil extract of *Monodora myristica* for steel with zinc in a seawater environment, it showed that it has the following efficiencies as shown in Figure 3. From the plots, the efficiencies increase as the volumes of the oil extract increase, that is, moving from the negative value, which is suggested to be due to the effect of the calcareous deposit on the surface of the steel, to the positive value, which is also a result of the dissolution of the deposit. However, on the other hand, in 0.1M sulphuric acid, the cathodic protection and oil extract for steel with zinc, it has an inhibition efficiency of 99% at 1 mL and 102.8% at 15 mL as observed in Figure 4. This is similar to the previous work by Aballe [34], who reported

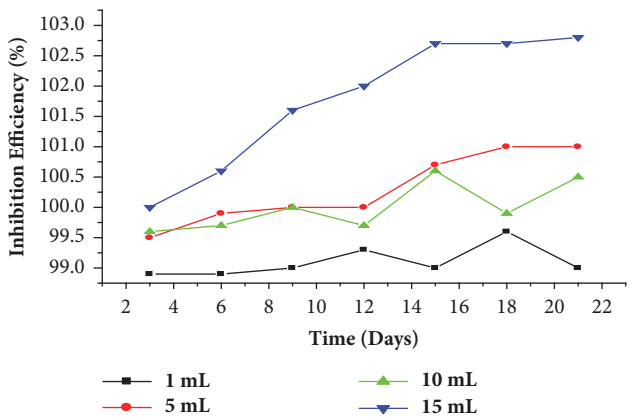

Figure 4: Variation of inhibition efficiency against time for the cathodic protection and different volumes of oil extracts for steel with zinc in 0.1M sulphuric acid.

inhibition efficiency greater 100%. This result suggests that the synergy of cathodic protection and oil extract of steel with zinc in 0.1M sulphuric acid showed a very strong adsorption bond between the oil extract molecule and the surface of the metal, which is also supported by the sacrificial zinc anode. Hence, in 0.1M sulphuric acid, the synergy of cathodic protection and oil extract of steel and zinc have a very high and good inhibition efficiency when compared to that of seawater counterpart

3.2. Linear Polarization Resistance (LPR) Measurement. The linear polarization resistance plot (Tafel) for the cathodic protection and oil extract for steel with zinc in both seawater and 0.1M sulphuric acid in the absence and presence of different volumes of oil extract of *Monodora myristica* is shown in Figures 5 and 6 and their electrochemical parameter obtained by extrapolation of the Tafel line is shown in Tables

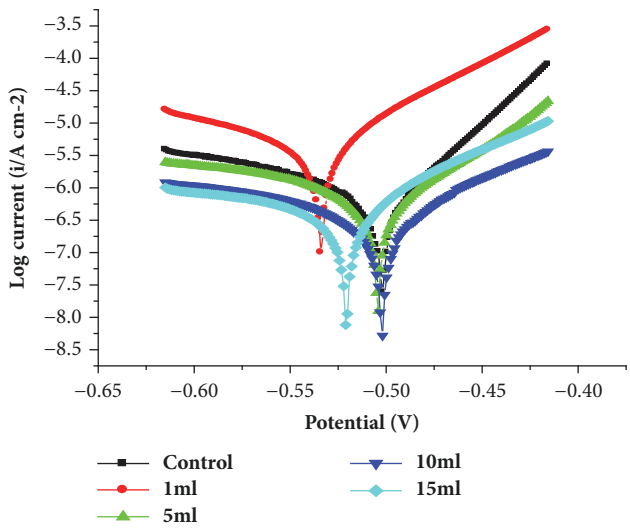

Figure 5: Variation of potential (E) against log current (A) for different volumes of oil extract and cathodic protection of steel with zinc in seawater.

4 and 5. The inhibition efficiency (IE%) for this process was calculated using the mathematical formula [35]

$$I.E\,(\%) = \frac{I_o - I}{I_o} \times 100 \tag{9}$$

where I_o is the corrosion density current measured for mild steel free-inhibitor and I is the corrosion density current containing the oil extracts, respectively. The polarization curve for the cathodic protection and oil extract for steel with zinc in seawater is shown in Figure 5, and the electrochemical parameter is shown in Table 4.

For the cathodic protection and oil extract of steel with zinc in seawater with different volumes of oil extracts of *Monodora myristica,* it is observed from the Tafel plot that the corrosion current density (Icorr) values at 1 mL are greater than every other current with a corrosion potential (E_{corr}) value that is shifted toward the negative. This shows that the cathodic protection and oil extract of steel with zinc in seawater could not resist the corrosion reaction taking place on the surface of the metal due to its very low polarization resistance (5664Ω) as seen in Table 4. Due to the high corrosion currents, corrosion potential shifts toward the negative side, and a low polarization resistance, the inhibition efficiency of the oil extract at that volume has a negative value (-306.95%), which suggests that the metal is not protected as both the cathodic and anodic reaction are activated, thereby increasing the rate of corrosion at that point. Apart from that, the corrosion current (icorr) decreases as the volume of the oil extract increases and the polarization resistance increases as the corrosion current decreases and, also, as the oil extract increases. It is also observed that inhibition efficiency increases as the volume of the oil extract increases, with values of 54.8%, 78%, and 78.8% for 5, 10, and 15 mL, respectively as seen in Table 4. The corrosion potential (E_{corr}) values shifted toward the positive, except for 1 and 15 mL which tend toward the negative and also alter the values of the cathodic and anodic Tafel plots. The same trend occurs with the value of OCP. However, when compared to that of cathodic protection and oil extract of *Monodora myristica* steel with zinc in 0.1M sulphuric acid, the corrosion potential (E_{corr}) tends to shift greatly toward the positive, which therefore causes a change in the cathodic and anodic Tafel slope as shown in Table 5. Typical Tafel plot shows that the corrosion current has a maximum value at free-inhibitor and the minimum at 15 mL of the oil extracts as shown in Figure 6. This suggests that it decreases as the volume of the oil extract increases. This leads to an increase in polarization resistance (Ω) as seen in Table 5. A striking difference between the cathodic protection and oil extract of steel with zinc in seawater and that of 0.1M sulphuric acid is that of inhibition efficiency. It is observed that the inhibition efficiency of steel with zinc in 0.1M sulphuric acid is higher than that of the seawater counterpart. It was shown that it has values ranging from 100% for 10 and 15 mL of oil extracts to 99% and 96.97% for 5 and 1mL, respectively, as seen in Table 5. The OCP value shows that it is shifted toward the positive values. The change in the cathodic and the anodic Tafel slopes data showed that the inhibitor is a mixed-type inhibitor. According to Rigg, (1973), only when the change in OCP values is more than 85mv, it can be recognized as a classification evidence of a compound as anodic or a cathodic type inhibitor. The OCP values were not anywhere closed to 85mV; hence, the inhibitor is referred to as a mixed-type inhibitor.

3.3. Adsorption Isotherm. Adsorption characteristics of *Monodora myristica* were studies to understand the mechanism of interaction between the oil extract and mild steel. It is a good practice to find out the likely adsorption mode by testing the experimental data with some adsorption isotherm. Thus, the obtained values were applied to different adsorption isotherms equations, and Langmuir adsorption isotherm equation fitted best as shown in Figure 7 for 0.1M sulphuric acid, with an R^2 value of 1 unit, indicating a good agreement with the experimental data and with Langmuir adsorption isotherm.

4. Conclusion

For the synergistic effect of cathodic protection and oil extract for steel with zinc, it was observed that in seawater, the synergism was not too effective for the protection of steel, whereas in 0.1M sulphuric acid, there was a great synergism between cathodic protection and the oil extracts of *Monodora myristica*, which possesses an inhibition efficiency (IE%) of 102.89% at 15 mL of the oil extracts. For the linear polarization resistance (LPR), in most of the cases, there is a slight shift of the corrosion potential (E_{corr}) and the open circuit potential (OPC) toward the positive as the volume of the oil extracts increased, thereby causing a change in the cathodic and the anodic Tafel slopes, which showed that the inhibitor is a mixed-type inhibitor. And, the corrosion current density (icorr) decreases as the volumes of the oil extract increase. For the adsorption isotherm, Langmuir adsorption isotherm

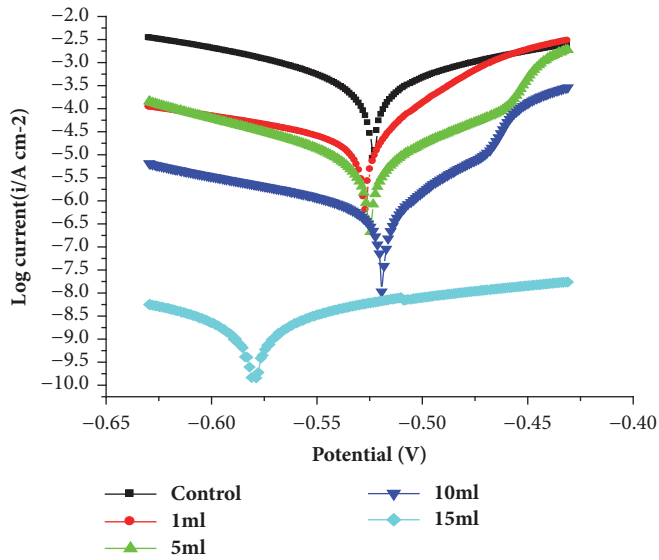

Figure 6: Variation of potential (E) against log current (A) for different volumes of oil extracts and cathodic protection of steel with zinc in 0.1M sulphuric acid.

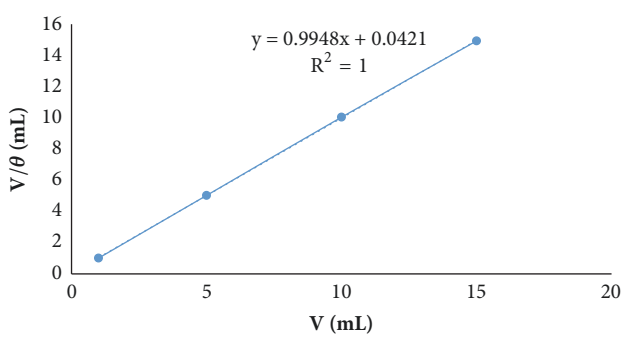

Figure 7: Langmuir isotherm of *Monodora myristica* on the synergism of steel and zinc in 0.1M sulphuric acid.

fitted best for it with an R^2 of 1 unit, indicating a good agreement with the experimental data and with Langmuir adsorption isotherm.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

Oladega Soriyan is on sabbatical leave from Obafemi Awolowo University, Ile Ife, Nigeria.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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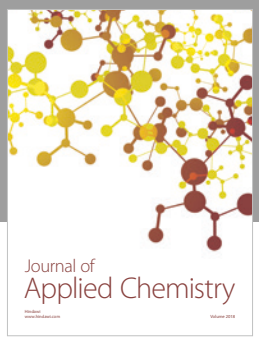

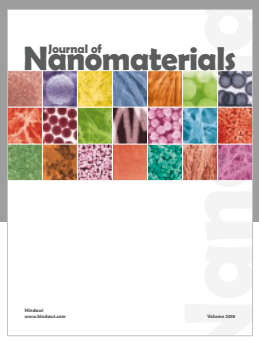

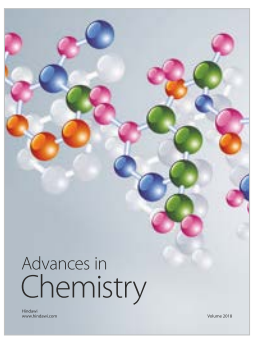

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