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INHIBITIVE EFFECT OF LOCALLY DIOSCOREA SPP LEAF EXTRACTS AS A GREEN CORROSION INHIBITOR IN SELECTED MEDIA

B. J. Ifeanyichukwu[1]
and
N. E. Idenyi[2]

Department of Industrial Physics,
Ebonyi State University, Abakaliki,
Ebonyi state, Nigeria[1&2].

ABSTRACT
In this study, the inhibiting effect of Dioscorea spp leaf extracts was investigated on the corrosion of mild steel in selected media using the weight loss method. The mild steel samples were pre-weighed and immersed in NaOH, NaCl and H_2SO_4 solutions respectively containing the leaf extracts, with the control samples immersed in solutions of the media containing no extract. The samples were allowed to stand for 672 h, with a set of samples from each environment withdrawn at intervals of 168 h for corrosion characterization. The results obtained from all the environments indicate that the corrosion rate increased as concentrations of Dioscorea spp increased. Results also confirmed that the extract functioned as an effective and excellent inhibitor in the alkaline, salt, and acidic media. Conclusively, it was proven that the higher concentration of Dioscorea spp leaf extracts in the media had the best inhibition characteristic on the mild steel in the selected environments. The results show good potential for application in manufacturing industries. The microstructure analysis of the various test coupons in the test media should be carried out in order to reveal the influence of the addition of the leaf extracts to the stimulated media on the grain structure distribution of the mild steel.

Key words: Mild Steel, Corrosion Rate, Dioscorea spp, NaOH, NaCl, H_2SO_4.

INTRODUCTION
The uses of the new green inhibitors have recently attracted increasing attention in the technology community. Scientists are tenacious in their pursuit of better and more effective techniques to stop the corrosion of metals in the field of material science and corrosion control (Idenyi et al., 2015:158-163; Idenyi et al., 2015: 245-250; Idu et al., 2015).

Since leaves contain corrosion-aggressive substances like tannins, saponins, and flavonoids, among others (Jamiu and Olorunfemi, 2013), the effects of corrosion on building materials and the maintenance or replacement of goods lost or contaminated by corrosion reactions are of remarkable consequence in the food processing industry. More harm than good has been caused by corrosion (Shadma et al., 2015; Kowsari et al., 2014).

Inhibition is a technique frequently employed to lessen the corrosive attack on metallic materials. Typically, inhibitors are used for this purpose to regulate metal dissolution. Recent investigations on the corrosion of mild steel in acidic solutions have surfaced in the literature.The important materials used in the manufacturing sector are mild steel. Mild steel is widely used in the construction of machine parts that are employed in manufacturing, processing, and production industries (Anyanwu et al., 2014; Anupama et al., 2016; Benali et al., 2013). The best approach to militate corrosion of these structures is to study the corrosive behavior of this metallic material in the environment concerned to proffer an appropriate method of protection (Helen et al., 2014; Mohsin et al., 2014). Mild steel corrodes when exposed to air and the oxide formed on it is readily broken down, in the presence of moisture, especially if it is not repaired (Mourya et al., 2014).

Furthermore, because the entire concept of metal protection is based on economic gain and environmental sustainability, the substance used as a metal corrosion inhibitor must be inexpensive, widely available, and environmentally friendly. As a result, research efforts are focused on developing a replacement for inorganic metal corrosion inhibitors. The leaf is a source of inexpensive, readily available, non-toxic green metal corrosion inhibitors. Leaf Products are organic and contain photochemical substances such as tannins, flavonoids, saponins, organic and amino acids, alkaloids, and pigments that can be extracted using simple, low-cost methods. Extracts from various parts of leaves have been widely reported as effective metal corrosion inhibitors in a variety of corrosive media (Nnanna et al., 2016; Nnanna et al., 2014; Odewunmi et al., 2015).

Various research works have been carried out in recent times on the use of vegetable extracts as corrosion inhibitors (Idu et al., 2016; Hussin et al., 2016). The research interest has been necessitated by the fact that the present corrosion inhibitors in the market for the protection of mild steel in the alkaline media are hazardous to the environment and thus compromise safety and sustainability drives (Onuegbu et al., 2013). There is, therefore, the need to develop inhibitors that are eco-friendly and sustainable. It is, however, noteworthy that the results of these studies show that extracts of the leaf are at the top of the list of non-toxic organic that has been used as corrosion inhibitors to replace environmentally hazardous synthetic. They are non-toxic, environmentally friendly, and readily available. Extensive research has been conducted to identify the synergistic effect of other additives on the efficiency of metal corrosion inhibitors. Osita et al. (2015), Raja et al. (2013:292-301) and Shainy et al. (2016:20-24), observed that synergism can improve an inhibitor's inhibitive force, reduce the amount of inhibitor used, and diversify the inhibitor's application in an aggressive environment.

In various years, many researchers, scholars, and organizations globally have carried out a lot of research on the evaluations of plant extracts as corrosion inhibitors, for example, Origanum vulgare (Callister, 2007), Sapium ellipticum (Dhaundiyal et al., 2019), Persian liquorice (Onukwuli, et al., 2020), Chicory aqueous (Sanaei et al., 2019). This green approach has received favorable attention owing to its availability, low cost, and to the best of our knowledge little or no negative effect on the environment has been documented. The present study is concerned with an investigation of the inhibiting effect of Dioscorea spp leafy extracts on the corrosion of mild steel in selected environments by using the weight loss method. It represents a modest effort to contribute to this growing field of research on the inhibitory behavior of leaf extracts on the corrosion of mild steel in selected media.

MATERIALS AND METHODS

Materials

The materials that were used for this study include the following: mild steel rods, hacksaw, lathe machine, electronic weighing balance METTLE TOLEDO model ME204E, beakers (100cm3, measuring cylinder (1000cm3), volumetric flask (250cm^3), masking tape, sandpaper, nylon thread, hand towel, razor blade, retorts stand, paper sieve, funnel, distilled water, Dioscorea spp leaf extracts. The chemicals that were used were Acetone, tetraoxosulphate (vi) acid (H_2SO_4) sodium chloride (NaCl) and sodium chloride (NaCl)..

Material preparation

This study made use of mild steel rods. The mild steel rods' composition was determined using an Optical Emission Spectrometer, and the mild steel rods were obtained from metal stockists. The chemicals and reagents used in this study were of the highest quality. A lathe machine and a hacksaw were used to machine cylindrical mild steel samples with diameters of 8 mm and heights of 16 mm. Each coupon was degreased by washing in ethanol, drying in acetone, and storing in a desiccator before being weighed and inserted into the beaker to determine the weight difference.

Preparation of leaf extracts

The leaves were collected in Edda-Echara, Ebonyi State, and identified by a laboratory technologist at Ebonyi State University's Department of Applied Biology in Abakaliki, Nigeria. Using standard laboratory procedures, 20g of Dioscorea spp. leaf extracts were obtained. The leaf extract volumetric concentrations were expressed in milliliters (ml).

The concentrations of Dioscorea spp leaf extracts used in the study were 5 ml, 10 ml, and 15 ml, respectively, while the concentrations of acid, alkali, and salt were 0.5 M and 1.0 M. A total of twenty beakers were rinsed with distilled water and dried in the air before the experimental was set up, to avoid additional water. The coupons were immersed in various media using a nylon thread that was tied to the coupons and hung on a retort stand. Mild steel samples were placed in beakers and left to stand for 28 days (672 h), with one set withdrawn every 7 days (168 h). To avoid crevices and galvanic corrosion, none of the coupons were allowed to touch.

Weight loss method

The mild steel sample coupons were weighed using a digital

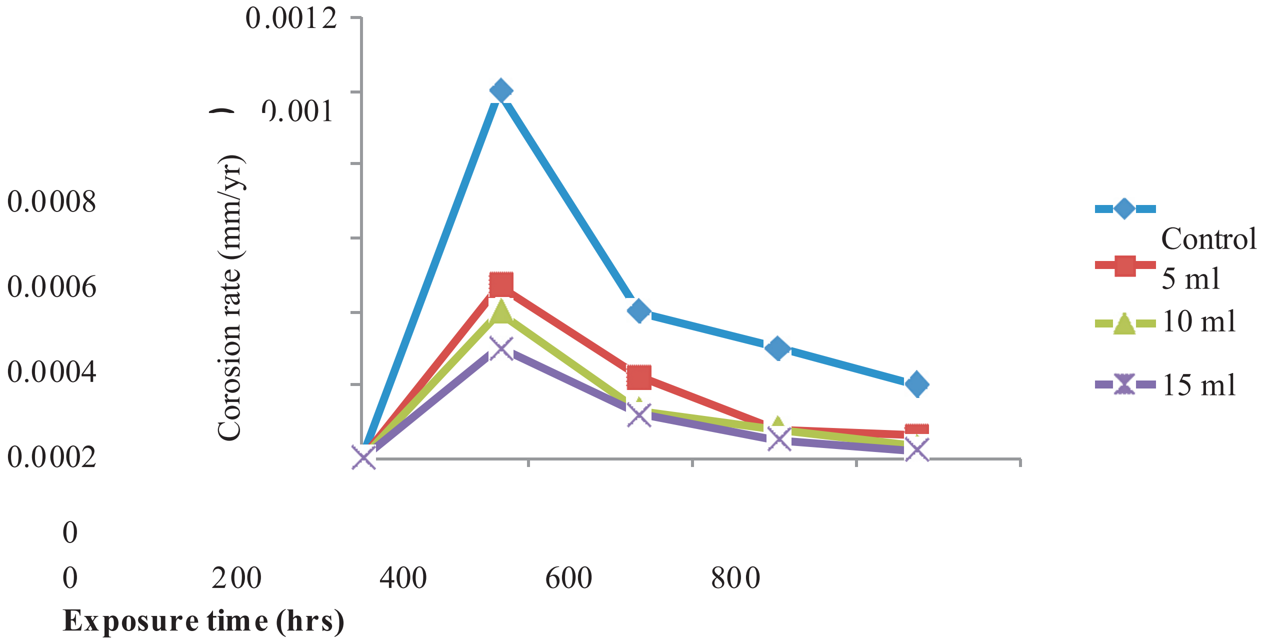

Figure 1. The graph of corrosion rate (mm/yr) against exposure time (h) for Dioscorea spp leaf extracts in 0.5 M NaOH media.

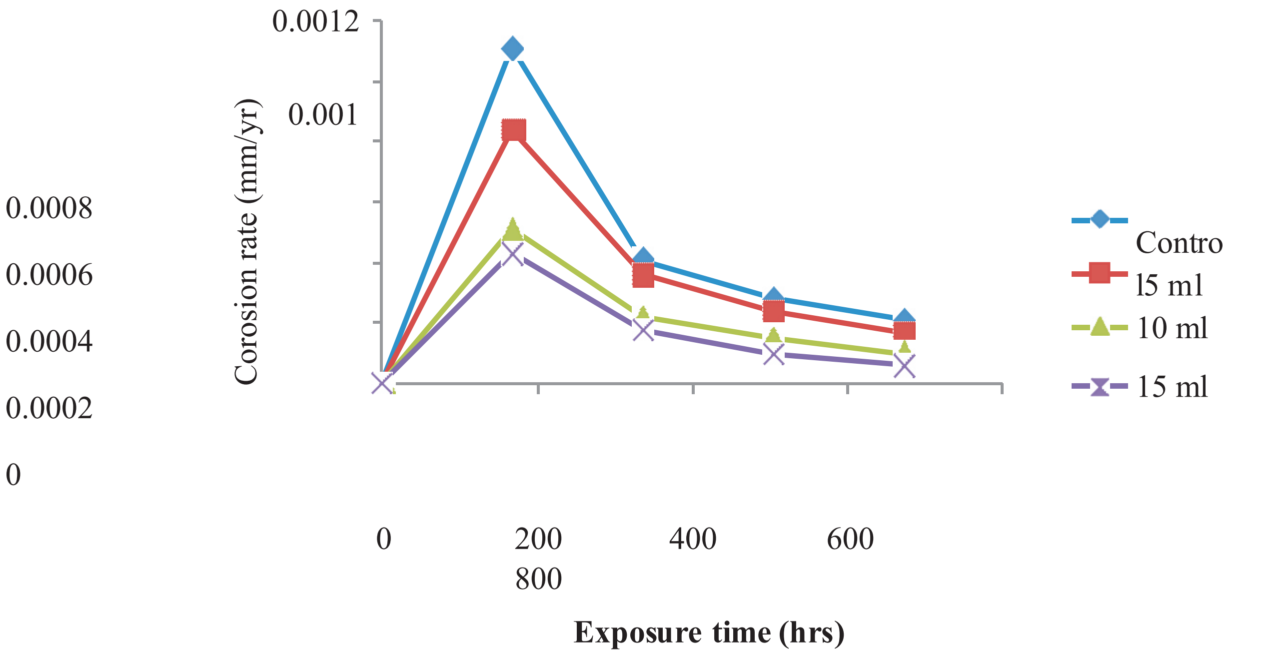

Figure 2. The graph of corrosion rate (mm/yr) against exposure time (h) for Dioscorea spp leafextracts in 1.0 M NaOH media.

weighing balance, METTLER TOLEDO model ME204E with a least count of 0.0001g, labeled, and immersed in the acid, alkali, and salt with inhibitor test solutions. The weight loss of each sample coupon was calculated and recorded. The weight loss determination and recording were repeated every 68 h (7 days) for a total of 672 h (28 days). Each coupon was washed in absolute ethanol, rinsed in distilled water, dried in acetone, and weighed before being measured (Callister, 2007). The same experiment was carried out in both the absence and presence of the inhibitor. The corrosion rate of leaf extracts was calculated using Equation 1

$$\text{Corrosion Rate} = K\Delta W/\Delta AT \qquad (3)$$

Where CR is corrosion rate, millimeter per year (mm/yr), K is rate constant equal to 87.6×10^4, ΔW is weight loss in mg, ρ is density of material in gcm^{-3}=$7.86gcm^{-3}$, T is exposure time in hours, A is exposed area of coupon in cm^2.

RESULTS AND DISSCUSIONS

Figures 1 to 6 give the graphical variation of corrosionrate with exposure time as obtained from weight loss

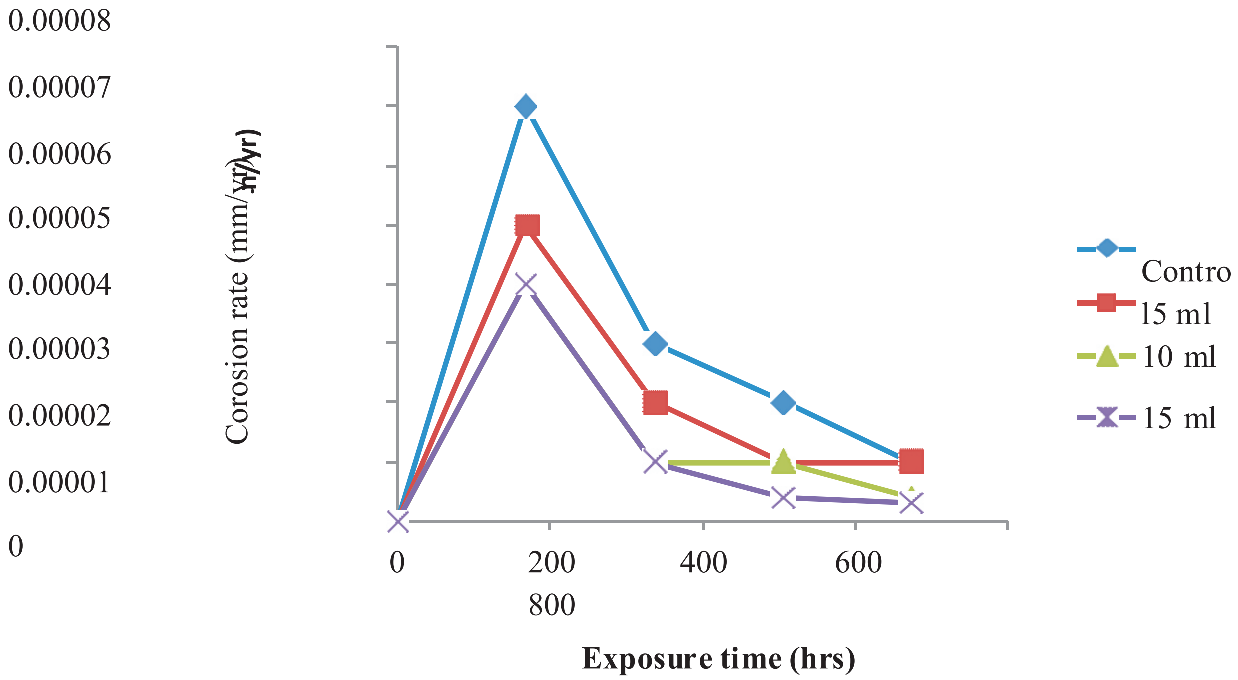

Figure 3. The graph of corrosion rate (mm/yr) against exposure time (h) for Dioscorea spp leafextracts in 0.5 M NaCl media.

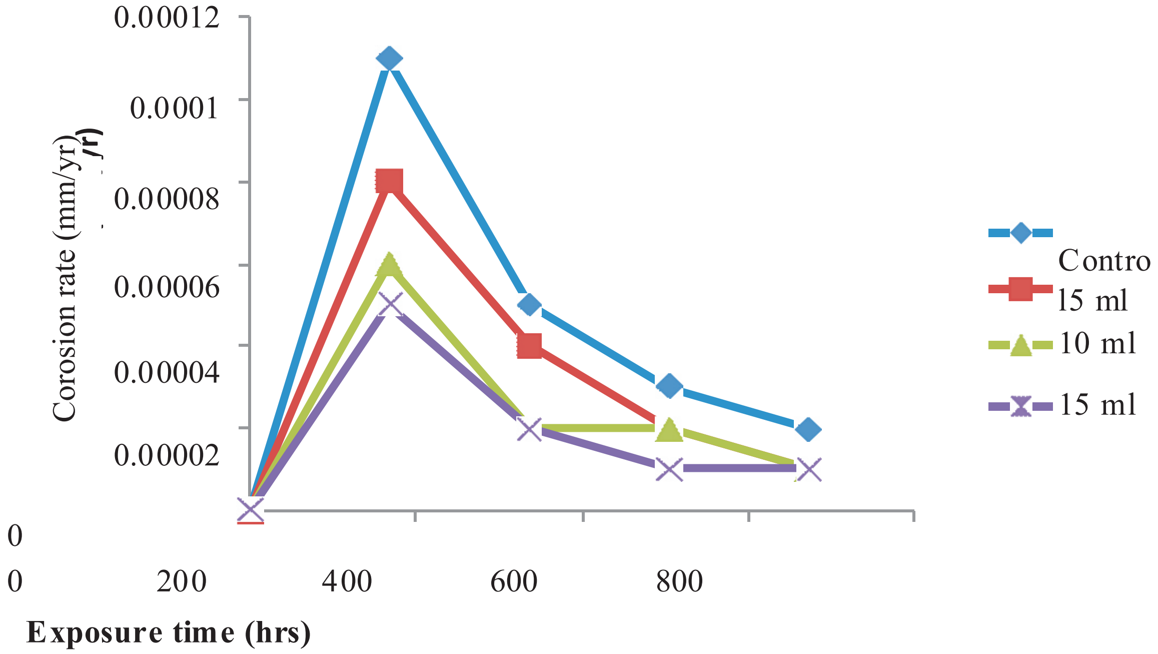

Figure 4. The graph of corrosion rate (mm/yr) against exposure time (h) for Dioscorea spp leaf extracts in 0.5
M NaCl media.

Measurements.
Figure 1 shows the results obtained for the variation of corrosion rates with exposure time for mild steel specimens immersed in 0.5 M NaOH with varying concentrations of added Dioscorea spp leaf extract. The results show a high corrosion rate for the test media without Dioscorea spp leaf extract. When Dioscorea spp extract was added to the test media, the corrosion rate was reduced. The difference in corrosion rate between the test media with and without Dioscorea spp extract was significant for the 168 h interval, but there was a decrease in corrosion rate for the media without

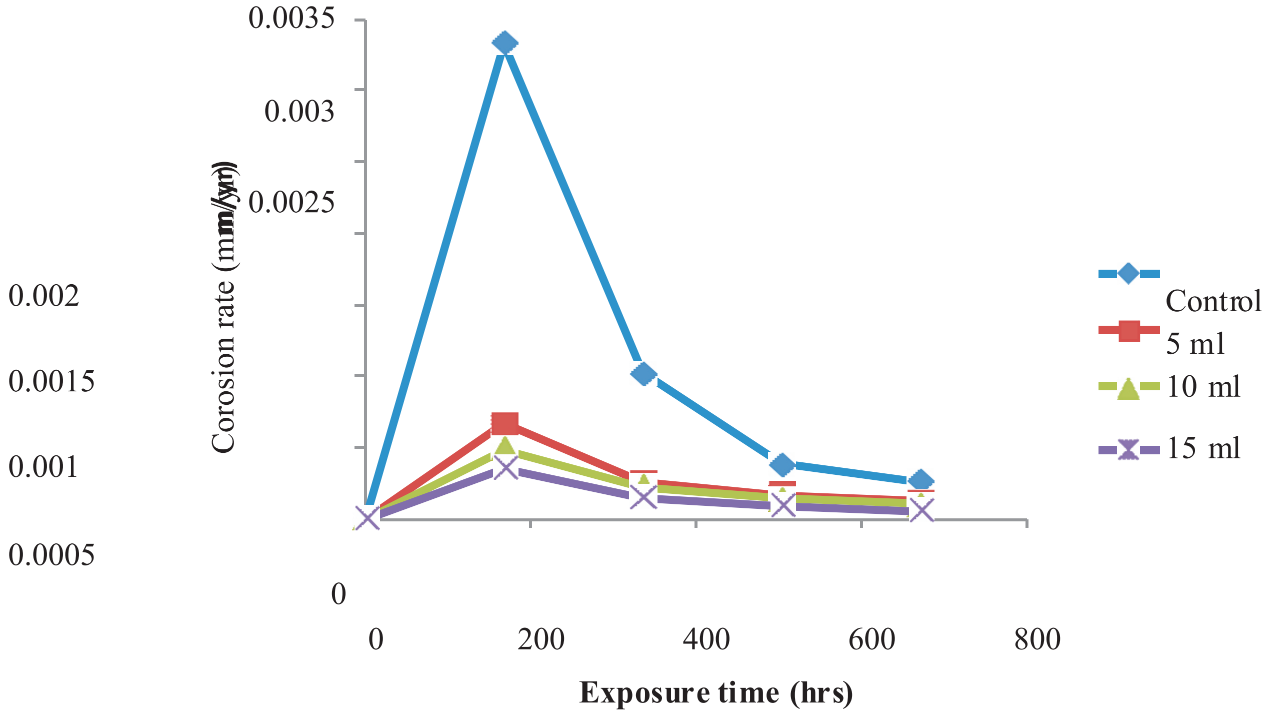

Figure 5. The graph of corrosion rate (mm/yr) against exposure time (h) for Dioscorea spp leaf extracts in 0.5M H_2SO_4 media.

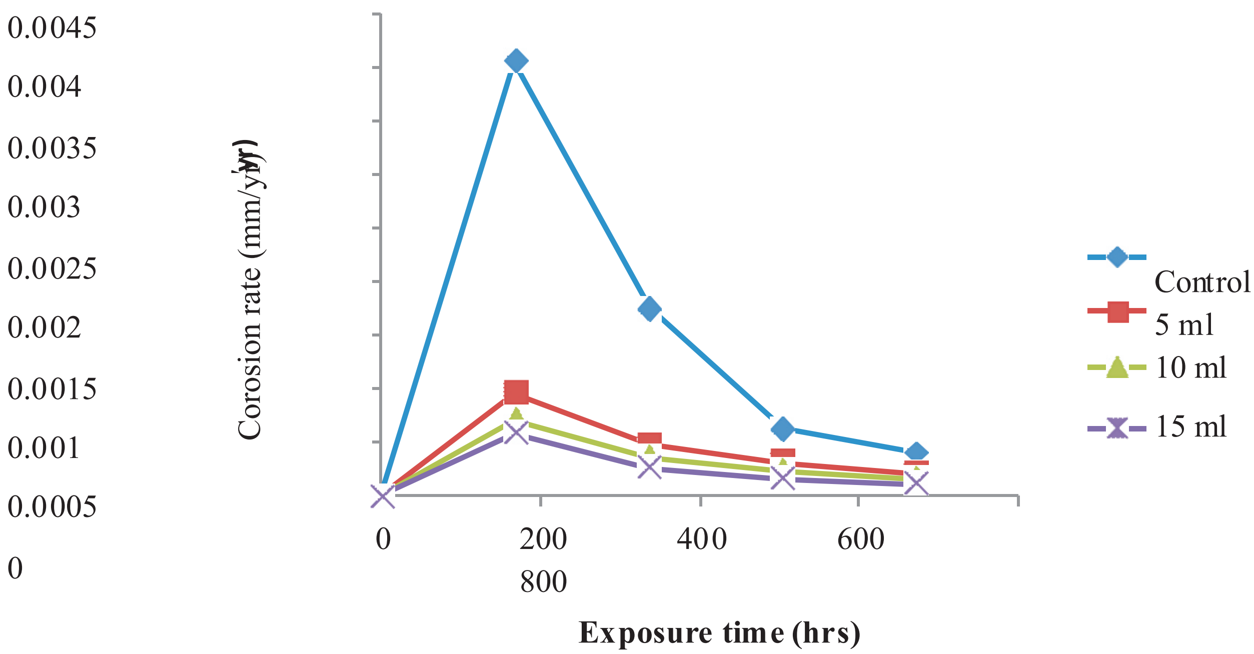

Figure 6. The graph of corrosion rate (mm/yr) against exposure time (h) for Dioscorea spp extracts in 1.0M H_2SO_4 media.

Dioscorea spp extract from 336 to 672 h (control experiment). In 0.5 M NaOH media, the Dioscorea spp extract inhibits the corrosion rate of mild steel well. This corresponds to the findings in the literature (Kowsari et al., 2014; Anyanwu et al., 2014; Osita et al., 2015).

Figure 2 depicts the variation of corrosion rate with exposure time for mild steel immersed in 1.0 M NaOH with various concentrations of Dioscorea spp leaf extract. Corrosion rates were extremely slow with all three Dioscorea spp extract concentrations. Throughout the experiment, the control experiment produced higher corrosion rate values. These findings confirm that a plant extract of Dioscorea spp. has corrosion-inhibiting properties. However, it is unclear whether any of the three concentrations used achieved the optimum concentration required for more effective corrosion inhibition. This suggests that Dioscorea spp. leaf extracts are a good and efficient inhibitor of mild steel corrosion in the environment.

Figure 3 depicts the results obtained for the variation of corrosion rate 0.5 M NaOH. The control experiment has the highest magnitude of corrosion rate in the graph because Dioscorea spp extract was not added. The addition of Dioscorea spp extracts to the test medium significantly reduced corrosion throughout the experiment. The results obtained for the addition of 5, 10, and 15 ml of Dioscorea spp extract to the test medium all showed a similar trend in corrosion rate, indicating that a small amount of extract has an inhibitory effect. The results confirmed the Dioscorea spp extract's excellent corrosion inhibition of mild steel in 0.5 M NaOH.

Figure 4 depicts a graph of corrosion rate variation. The addition of Dioscorea spp extracts to the test medium significantly reduced corrosion rate throughout the experimental period when compared to the control experiment. The corrosion rate values obtained for the 5, 10, and 15 ml Dioscorea spp extract additions to the test medium are close.

The results confirmed the extract of Dioscorea spp's effectiveness on the corrosion rate of mild steel in 1.0 M NaOH media. The extract concentration of 15 ml addition appeared to be the best, with corrosion rate values of 0.00005, 0.00002, 0.00001, and.00001 mm/yr for 168 to 672 h, respectively, followed by Dioscorea spp concentrations of 10 and 5 ml (Nnanna et al., 2016).

Figure 5 shows the corrosion rate of mild steel in the absence and presence of Dioscorea spp leaf extract at various concentrations of leaf extract in 0.5 M H_2SO_4 media. The plot clearly shows that the typical corrosion profile for passivating metals was observed. This is characterized by a sharp increase in corrosion rate followed by a gradual decrease as the duration time increased. The corrosion rate decreased rapidly in the first seven days of the experiments before slowing down. This is due to the formation of thin film oxide on the coupon's surface, which served as a barrier between the coupon and the media. The figure also confirmed that as the concentration of Dioscorea spp extract increases, the loss in the corrosion rate of the coupons decreases, indicating that the leaves extract has good corrosion inhibition performance in the acidic environment. This is consistent with the current research findings (Idu et al., 2016; Moha et al., 2022).

Figure 6 shows a graph of corrosion rate versus exposure time in the previously discussed Dioscorea spp extract concentrations in 1.0 M H_2SO_4 solution medium. As expected, the graphs display higher corrosion rates for the coupons subjected in control experiment (without Dioscorea spp extract). As with the Dioscorea spp extract media, the trend of a very high initial corrosion rate which drops very rapidly in the first seven days and then decreased less rapidly afterwards, may be noticed. These graphs also show that in general, the coupons subjected in these media experienced higher corrosion rates as compared to 0.5 M H_2SO_4 media. This finding is consistent with those of (Idenyi et al., 2015: 245-250; Anupama et al., 2016).

Conclusion

In this study, weight loss analysis of leaf extract was used to study the ability of Dioscorea spp leaf extract to retard the corrosion of mild steel in different concentrations of acidic, alkaline, and salt environments. The following conclusions are drawn:

i. The results indicated that the corrosion rates of mild steel increased with increasing concentration of leaves extract; at the highest inhibitor concentration of 15cm3, the inhibition efficiency increased markedly and reached 92 %.
ii. Dioscorea spp extracts are effective corrosion inhibitors for mild steel in both acidic and alkaline environments.
iii. The corrosion rate of mild steel is strongly influenced by the concentration of Dioscorea spp leaf extract.
iv. That Dioscorea spp leaf extracts act as good green corrosion inhibitors and can be used to slow the corrosion rate of mild steel if the appropriate concentration is used.
v. In all parts of Nigeria, the leaf extract (used as one of the corrosion inhibitors) grows and survives easily. The economic potential of the leaf extract is enormous. As a result, it should be widely planted throughout the country as one of the plant-derived corrosion inhibitors. This will reduce our reliance on toxic, non-environmentally friendly, and expensive corrosion inhibitors imported from other countries.
vi. Based on the findings of this study, it is necessary to conduct regular corrosion inhibition studies on other metals using this leaf extract (Dioscorea spp) to evaluate their efficiencies on such metals at different concentrations.

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