



Corrosion inhibition of zinc in acid medium by *Moringa oleifera* and *Mangifera indica* leaves extracts

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Abstract

The effect of *Moringa oleifera* and *Mangifera indica* leave extracts on the corrosion of zinc sheet in HCl solution was studied using ultraviolet spectroscopic technique. *Moringa oleifera* and *Mangifera indica* leave extracts inhibit the corrosion of zinc sheet in 0.5M HCl solution. The inhibition efficiency increases with increase in concentration of the extracts. The adsorption of the inhibitor molecules on Zinc sheet surface was in accordance with Langmuir adsorption isotherm. A first order kinetic relationship with respect to Zinc with and without the extract was obtained. The Infra red spectrograph of the leave extracts gave absorption peaks corresponding to – C=O, -C=N, C-OH and C=C functional groups. These functional groups could have reacted with surface of the Zinc sheet thereby preventing oxidation reaction. These functional groups were viewed to be from organic compounds such as Alkaloid, Saponins, Tannins, Phenolics in the leaves extracts. It is recommended that green extracts of *Moringa oleifera* and *Mangifera indica* could be used as corrosion inhibitors as against other inorganic compounds. They both have higher inhibitory efficiency, readily available, biodegradable, less costly and eco-friendly.

Keywords: Inhibitor, Corrodant, Biodegradable, Zinc Sheet, Metal, *Moringa Oleifera*, *Mangifera Indica*

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1. Introduction

Chemical decay of metals by the action of surrounding medium or environment is called corrosion (Wong et al., 2002). The corrosion of metals has received considerable attention over the years. Inhibitors are used to control the corrosion of metallic materials through controlling its dissolution and consumption leading to the formation of film on the metal surface (Aggarwal and Avinash, 2002). Inhibitors are usually organic compounds and other elements such as nitrogen, sulphur and oxygen which act as adsorption centre (Obot and Obi-Egbeli, 2010). Organic compounds contain hetero atoms such as N, S, O, polar groups and π electrons have been found to be very effective in inhibiting metallic corrosion when adsorbed on metallic surfaces. Physiochemical properties of the donor atoms, steric effects and electron density also contribute to the inhibition. Corrosion damages metals/alloys, engine parts of industrial machines/equipment, oil pipes, bottle tops, etc reduces their economic potentials. The possible replacement of these toxic and non-environmentally friendly chemicals with corrosion inhibitors by naturally occurring substances of plant origin has been of interest to scientists (Onen, 2004 and El-Abd, 2008). This work centered on the use of plants extracts of *Moringa oleifera* and *Mangifera indica* which are eco-friendly, less costly, biodegradable and readily available as inhibitors on Zinc sheet.

2. Materials and methods

2.1. Collection of materials

The Zinc sheet was obtained at Jimeta market of Adamawa State. The inhibitors (*Moringa oleifera* and *Mangifera indica*) leaves were sourced from Gawa in Katsina-Ala local Government Area, Benue State-Nigeria. Hydrochloric acid, Methanol, Ethanol, Propanone and Sodium hydroxide were obtained from British Drug House (BDH).

2.2. Preparation of zinc sheet

The Zinc sheets were mechanically cut into coupons of dimension 4 x 3 cm and thickness 0.038 cm with a hole drilled at one end for free suspension. The specimens were used without further polishing to ensure reproducible surface. They were however degreased in Ethanol, dried in Propanone and stored in moisture free desiccators before their use for the study.

2.3. Preparation of plant extract

Fresh leaves of *Moringa oleifera* (M.O) and *Mangifera indica* (M.I) were collected, dried and pulverized into powdering form. 200 mg each of the fine powder leave extracts were dissolved in 400 ml distilled water and methanol in round bottomed-flasks. The solution of leave extracts in distilled water were boiled, decanted

and filtered to produce the aqueous extract. The methanolic extract was concentrated on a rotary evaporator at 40°C after the usual decantation and filtration. 0.1-0.5 ml HCl were also prepared and used.

2.4. Measurement of absorbance

Five 250 ml beakers labeled A, B, C, D and E separately containing, 0.10, 0.20, 0.30, 0.40 and 0.50M HCl solutions were heated at the temperature of 303K. Absorbance (A_0) of each of the solutions was taken at a wavelength of 450nm using UV/visible spectrophotometer (Jenway 6405, Barloworld scientific, and USA). The Zinc coupon was then suspended in each of the beakers with the aid of glass hooks. These coupons were retrieved at 24 hours intervals progressively for 1668 hours. The absorbance (A_1) of solutions was again taken at a wavelength of 450 nm. The differences between A_0 and A_1 were recorded as the absorbance difference (ΔA) of the corrodant in each case. Further measurements of absorption at 450 nm were done after the introduction of the MO and MI inhibitors into the beakers containing HCl corrodant and maintained at 303K. Each of the reported readings was an average of seven experimental readings recorded to the nearest 0.0001. The difference in observance recorded for a period of 168 hours were recorded the total observance difference.

2.5. Calculation of inhibition efficiency (%)

The inhibitor efficiency ($\%I_E$) of M.O and M.I were calculated from the equation

$$\% I = \frac{(A_0 - A_1)}{A_0} \times 100 \quad (1)$$

where A_0 and A_1 are absorbance for Zinc metal in the absence and presence of inhibitor in HCl solution at 303 K and 380 nm (Onen and Nwufo, 2007)

The degree of surface coverage at each concentration of the inhibitor of M.O and M.I were determined using the relation

$$\theta = \left[1 - \frac{A_1}{A_0} \right] \quad (2)$$

Corrosion rate of Zinc in different concentrations of HCl and M.O and M.I were computed for 168 hours period from the absorbance difference measurements using the formula (Onen and Nwofor, 2007)

$$\text{Corrosion rate (Add)} = \Delta A/at \quad (3)$$

where ΔA is the absorbance difference, a ; is the area of Zinc coupons and t is the time of exposure in hours.

3. Results and discussions

3.1. Influence of corrodant concentration on zinc sheet

Variations of absorbance difference with time for Zinc corrosion in different concentration of HCl solution at 303 K are shown in Fig 1. It was observed that the absorbance increases with increasing acid concentration. Similarly, corrosion rate increases with increase in HCl concentration. These observations are in agreement with the result obtained by Onen, 2004 and Onen and Nwufu (2007). The observed trend may be due to the fact that the rate of chemical reactions generally increases with acid concentration.

Table 1. Summary of Average Absorbance Difference (AD), Corrosion rate (ADD), Inhibition Efficiency (%I_E) and Surface Coverage (A) for Zinc Sheet in 0.5M HCl with different concentrations of *Moringa oliefera*

Inhibitor conc.(gdm ³) MO	Absorbance difference(AD)	Corrosion rate	Inhibition efficiency (I _E)	Surface coverage (A)
0.1	0.302	0.539 x10 ⁻²	67.10	0.671
0.3	0.299	0.534 x10 ⁻²	69.20	0.692
0.5	0.297	0.530 x10 ⁻²	71.40	0.714
0.7	0.296	0.529 x10 ⁻²	73.40	0.734
1.0	0.295	0.520 x10 ⁻²	67.50	0.675

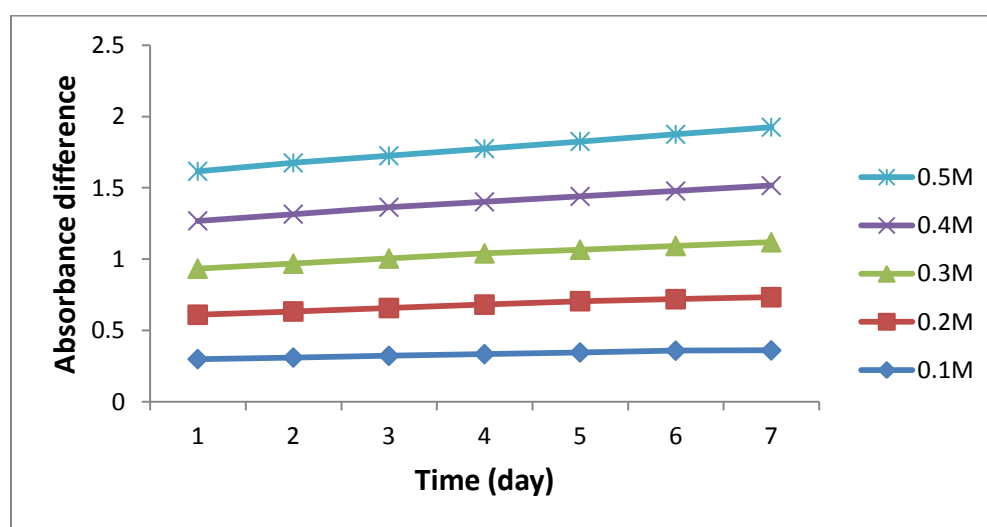
3.2. Effect of MO and MI inhibitors concentration on zinc sheet

Variation of absorbance difference with time for zinc sheet corrosion in 0.5M HCl with various concentration of M.O and M.I at 303K is shown in Fig. 2 and 3 respectively. It revealed that the absorbance difference was lowest at 1.00 gdm⁻³ for MO and MI. Thus the absorbance difference decreased with increasing in MO and MI concentration.

Table 1 and 2 shows the values of absorbance difference, corrosion rate, inhibition efficiency and surface coverage for zinc sheet corrosion in 0.5M HCl with MO and MI. The corrosion rate increases as the acid concentration increased but with the addition of the inhibitor MO and MI the corrosion rate decreases while the inhibition efficiency and surface coverage increase significantly with increase in concentration of the inhibitors.

Table 2. Summary of Average Absorbance Difference (Ad), Corrosion Rate (Add), Inhibition Efficiency (%IE) and Surface Coverage (A) For Zinc Sheet Corrosion in 0.5M HCl with Various Concentration of MI

Inhibitor conc.(gdm ⁻³)	Absorbance difference (AD)	Corrosion rate	Inhibition efficiency(I _E)	Surface coverage (A)
0.1	0.308	0.550 x10 ⁻²	47.450	0.480
0.3	0.306	0.546 x10 ⁻²	49.740	0.501
0.5	0.304	0.543 x10 ⁻²	51.970	0.530
0.7	0.302	0.539 x10 ⁻²	54.023	0.552
1.0	0.300	0.536 x10 ⁻²	58.761	0.590

**Figure 1.** Variation of Absorbance difference with Time (day) for Zinc corrosion in various concentration of HCl at 303 K

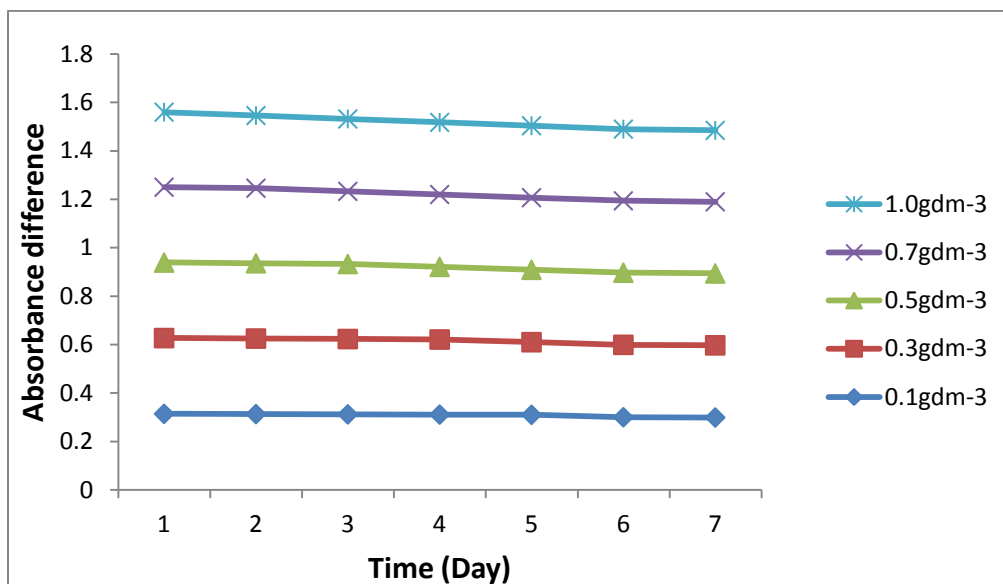


Figure 2. Variation of Absorbance difference with Time for Zinc corrosion in 0.5M HCl containing various Concentrations of MO at 303 K

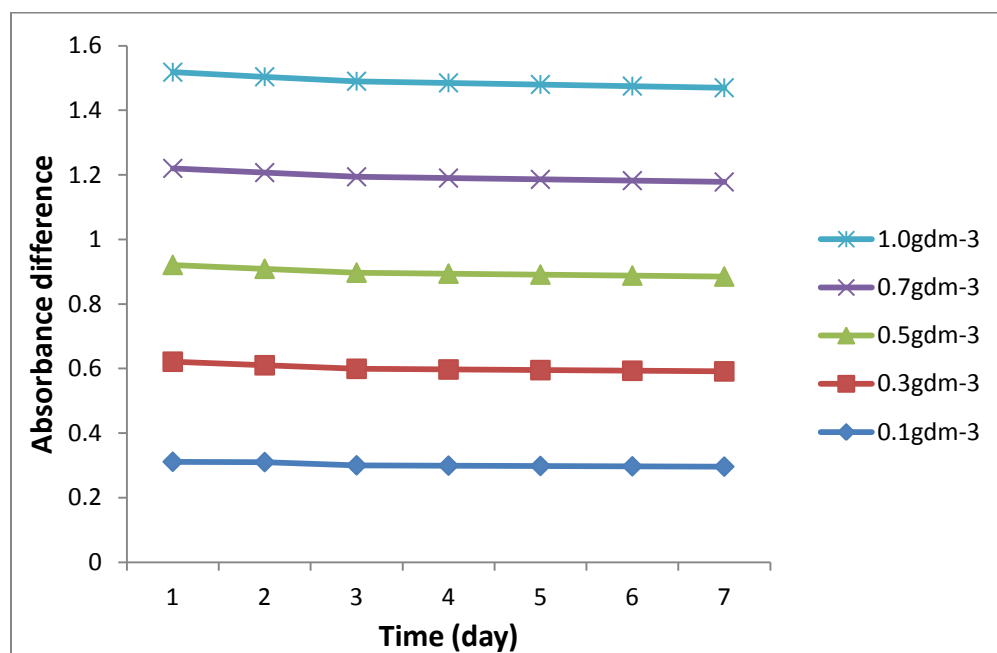


Figure 3. Variation of Absorbance difference with Time for Zinc corrosion in 0.5M HCl containing various concentrations of MI at 303 K

This result suggests that when the extract concentration increases, the number of inhibitor molecules adsorbed increases therefore, preventing the direct acid attack on the metal surface. The inhibition effect of MO and MI is ascribed to the presence of organic compounds in the extracts, with functional groups such as – C=O, C=N, C-OH, C=C, Ph-OH etc. These functional groups abstract the valence electrons in the metal and form

ionic bonds which contribute greatly to the inhibition effectiveness. These may have prevented other reactions on the Zinc surface occurring (Abdallah, 2003).

3.3. Rate of Inhibition

Figure 4 is a plot of absorbance difference versus time in difference concentrations of HCl without inhibitor whereas, Fig. 5 and 6 give the absorbance difference versus time in 0.5M HCl with MO and MI inhibitors. A linear variation was observed from these plots which signified a first order kinetics for the inhibition process.

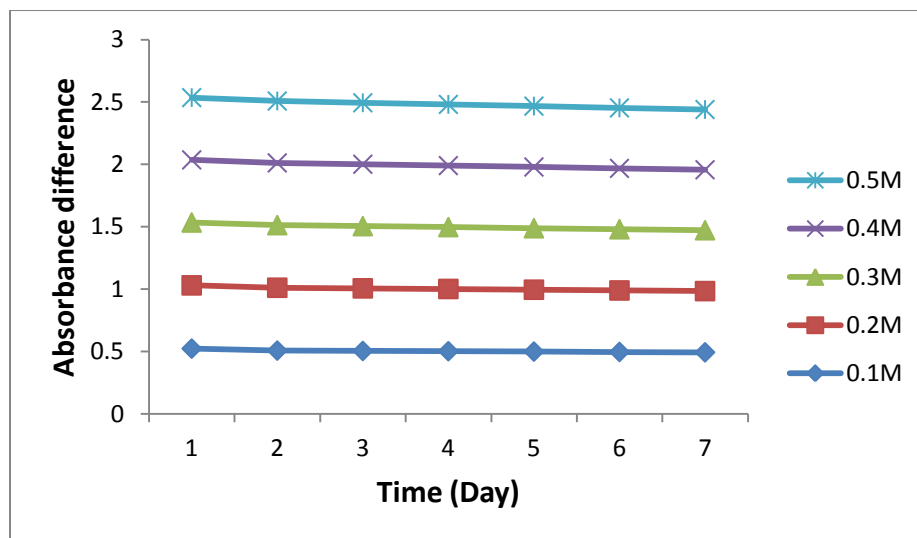


Figure 4. Absorbance difference versus Time for Zinc corrosion in various concentration of HCl at 303 K

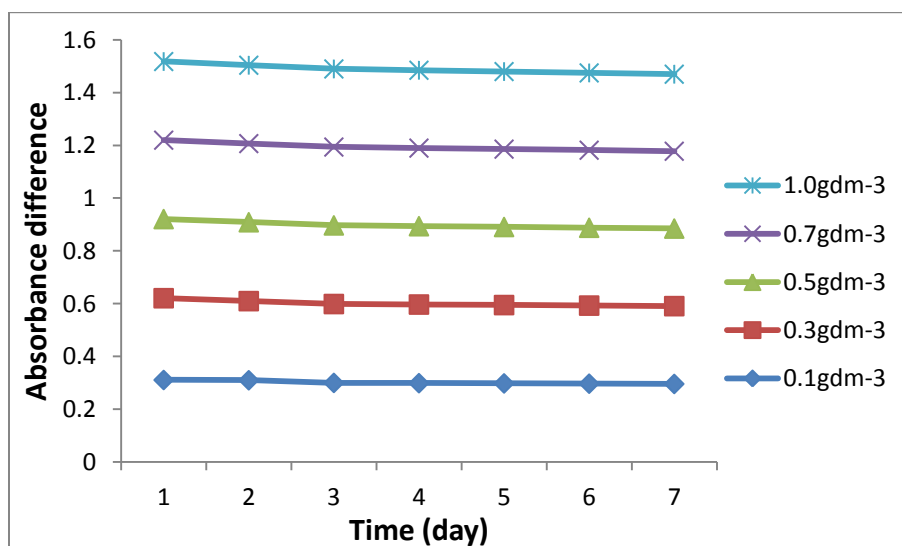


Figure 5. Absorbance difference versus Time for Zinc corrosion in 0.5MHCl containing various concentration of MO at 303 K

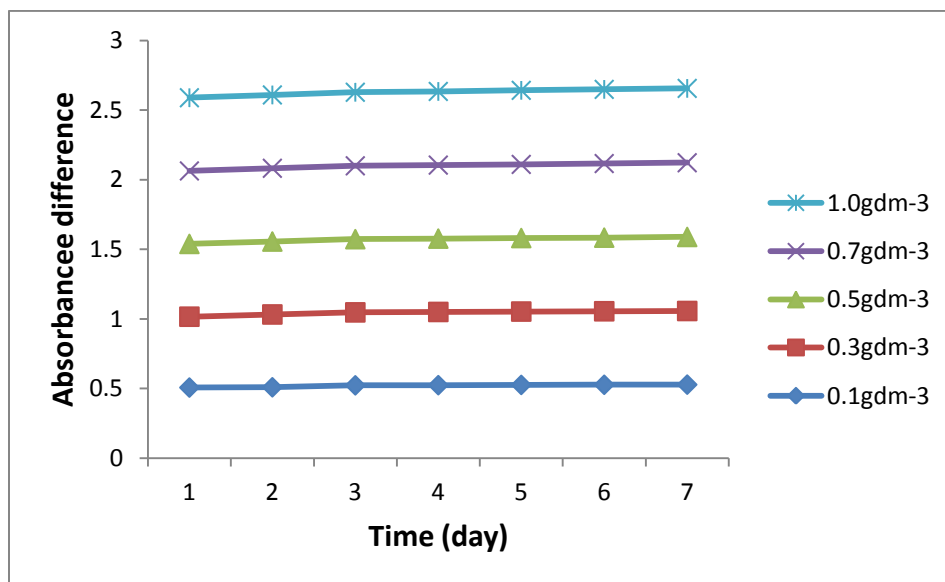


Figure 6. Absorbance difference versus Time for Zinc corrosion in 0.5M HCl containing various concentration of MI at 303 K

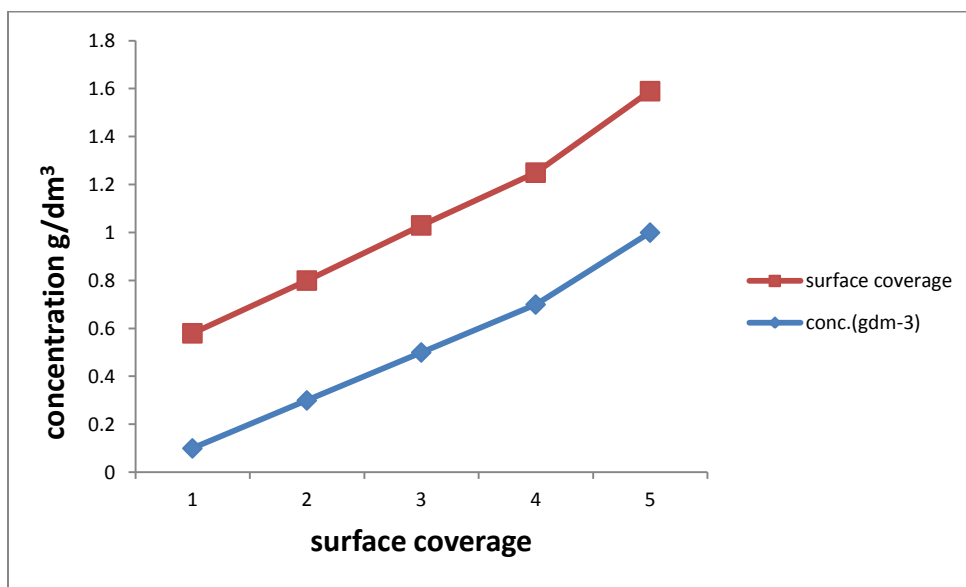


Figure 7. Concentration versus degree of surface coverage (MO) at 303 K

3.4. Measurement of absorbance

Table 1 to 2 and Fig. 7 to 8 revealed that the percentage inhibition efficiency and surface coverage increased with inhibitor concentration. This further confirms physical adsorption mechanism for the inhibition process (Abiola and James, 2010; Eddy and Egbeson, 2008). The high surface coverage observed at high inhibitor concentration could be due to very strong interactions between the adsorbed species and metallic surface.

The surface coverage data implies that the absorption of MO and MI at the Zinc sheet interface may be due to electrostatic forces between the atoms on the surface and the adsorbents. It is shown in the Table 1 and 2 that the MO has higher efficiency than MI. This could be due to differences in their chemical compositions (Onen *et. al.*, 2010).

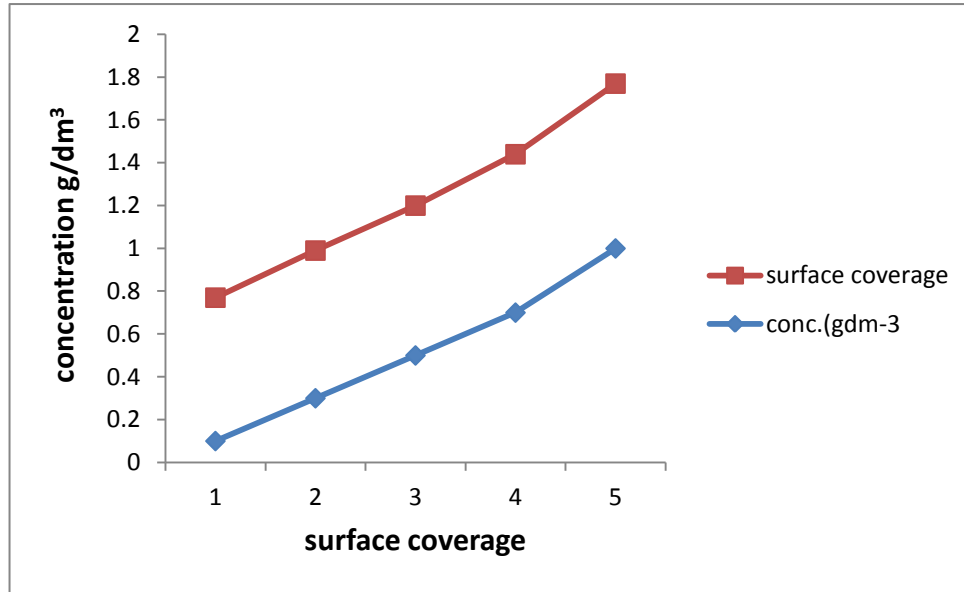


Figure 8. Concentration versus degree of surface coverage (MI) at 303 K

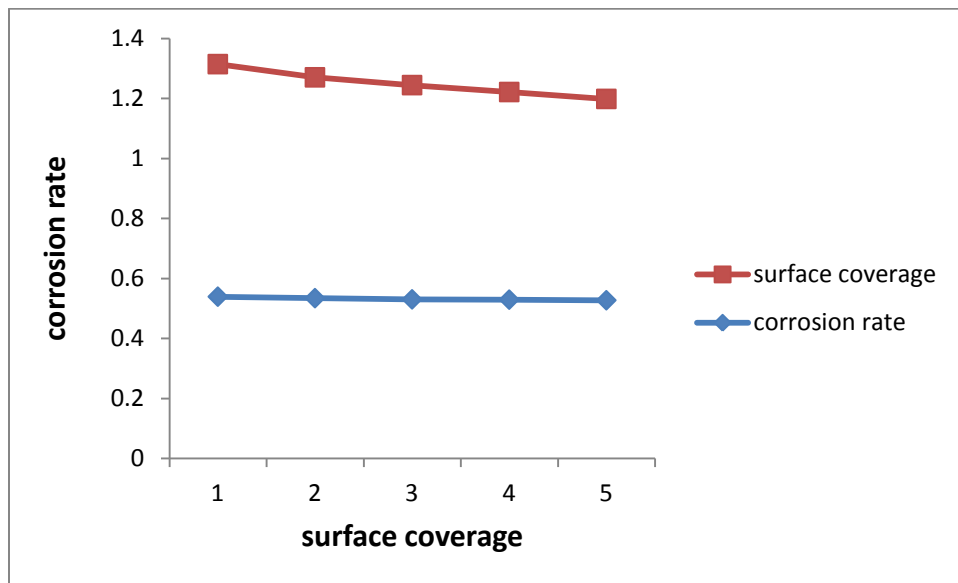


Figure 9. Corrosion rate against surface coverage (MO) at 303 K

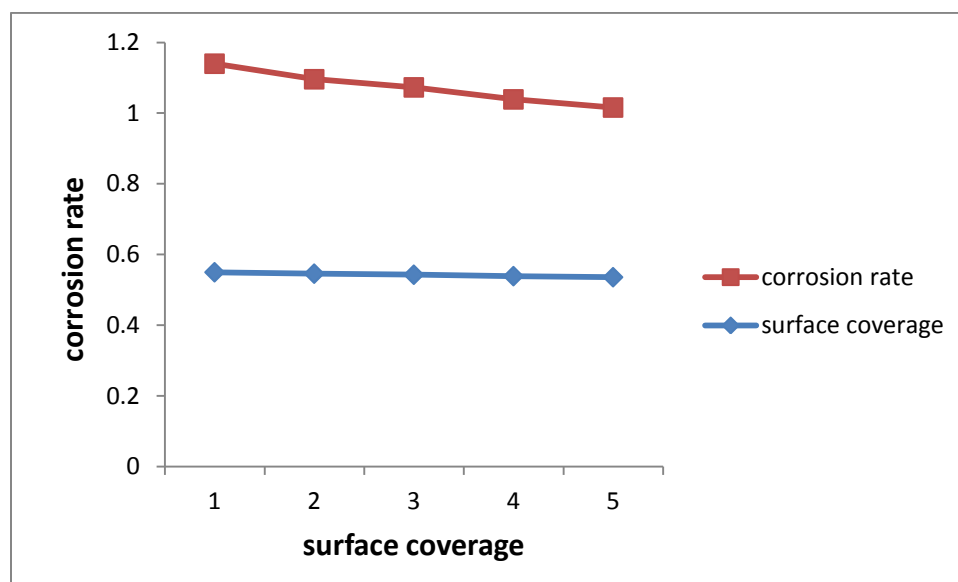


Figure 10. Corrosion rate against surface coverage (MI) at 303 K

4. Conclusions

Moringa oleifera and *Mangifera indica* inhibit the corrosion of Zinc in acid medium with high efficiency of 67.50 % and 58.75 % in 1.0 gdm⁻³ HCl respectively. Also, the surface coverage increases with increase in concentration of the inhibitor. This implies that the inhibitor strongly adsorbed on Zinc metal surface which causes the corrosion rate to decrease considerably. *Moringa oleifera* displayed stronger inhibition than *Mangifera indica*. The effectiveness of *Moringa oleifera* and *Mangifera indica* as inhibitors of corrosion on Zinc metal was attributed to the presence of organic compounds such as Alkaloids, Saponins, Tannins, and Phenols whose functional groups form strong ionic bonding with the metal surface. This could prevent the formation of any other bonds with other substances which would lead to corrosion.

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