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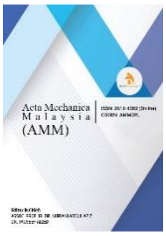

RESEARCH ARTICLE

# EVALUATION OF CORROSION INHIBITIVE PROPERTIES OF NATIVE BANANA (MUSA ACUMINATE COLLA) ON MILD STEEL IN 1M SULPHURIC ACID ($H_2SO_4$)

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**ABSTRACT**

Based on the weight loss method of analysis, the corrosion inhibitive properties of native banana (musa acuminate colla) extract on mild steel in 1M H2SO4 were evaluated, including the effect of inhibitor concentrations (blank, 0.2, 0.4, 0.6g/L), temperature (303.15, 313.15, 323.15, 333.15, 343.15K), and immersion time (2, 4, 6, 8, 10 hours). The results showed that a native banana extract (musa acuminate colla) inhibited corrosion in mild steel. The extracts' inhibition efficiency increased as the concentration of the extract increased, but decreased as the temperature increased. The plant's best inhibition efficiency was 90% at 0.2 g/L of extract at 343. 15K. The presence of native banana extract (musa acuminate colla) may be a good inhibitor because the rate of corrosion decreases noticeably. Adsorption isotherms and a comparison with known green corrosion inhibitors were used. The inhibitors' adsorption on the mild steel surface follows the Langmuir adsorption isotherm (R2 = 0.923) and compares favorably to many documented green inhibitors.

**KEYWORDS**

Corrosion inhibitor, native banana (Musa acuminate colla), adsorption, Langmuir isotherm

## 1. INTRODUCTION

Corrosion, also known as rusting, is an event of metal damage or loss of quality caused by a reaction with the environment. Corrosion phenomena, control, and prevention are unavoidable major scientific issues that must be addressed on a daily basis as the demand for metallic materials increases in all aspects of technological development ( Loto et al., 2015).

The consequences of corrosion are many and varied and the effects of these on the safe, reliable and efficient operation of equipment or structures are often more serious than simple loss of a mass of a metal. Failure of various kinds and the need for expensive replacements may occur even though the amount of metal destroyed is quite small, which involves huge sum of money that should have been used to provide basic social amenities in these countries. In practice corrosion can never be stopped but can be hindered to a reasonable level ( Umoren et al., 2009; Popoola et al., 2013).

Inhibitors are commonly used to prevent metal dissolution and acid consumption, as well as to slow the corrosive attack on metallic materials. Corrosion inhibitors are chemical compounds that are used in small concentrations in industry to reduce the corrosion rate of metals and alloys in contact with aggressive environments, thus retarding the corrosion process and keeping its rate to a minimum and preventing economic losses due to metallic corrosion. The mechanism of action of inhibitors is critical and is dependent on their formulation as well as their rational application in various environments. The adsorption degree is determined by the electronic properties of the adsorbate molecules, the chemical composition of the solution, the nature of the metallic surface, the temperature of the reaction, the immersion time, and the electrochemical potential at the metal–solution interface (Zarrouk et al., 2010).

Corrosion inhibitors, also known as synthetic chemicals, are widely used to protect metals from corrosion. As a result, the development of new corrosion inhibitors that are non-toxic, eco-friendly, natural, and have a low or "zero" environmental impact is desired (Ibrahim et al., 2012).

Native banana (musaa cuminate colla) extract is a rich source of naturally synthesized chemical compounds that is readily available, low-cost, and eco-friendly, and can be obtained through a simple extraction process that is both low-cost and biodegradable ( El-Etre, 2007; Nathaniel et al., 2020).

*Musa acuminata Colla* is a wild banana species native to Southeast Asia. In folk medicine, various parts of the Musa plant have been used orally or topically as remedies, and some studies have demonstrated this medicinal potential. It is well-known for its numerous pharmacological activities, and studies show that the phenolic compounds found in *Musa acuminate colla* play a significant role in this. In America, Asia, Oceania, India, and Africa, all parts of the plant, including the roots, stem, pseudostems, leaves, fruits, and flowers, have long been used in local and traditional medicine. The phytochemical analysis of *Musa acuminata fruit*, peel, flower, leaf, pseudostem, and rhizome revealed the presence of a diverse range of phytochemicals such as saponins, terpenoids, steroids, anthocyanins, fatty acids, tannins, phenols, and alkaloids (Kumar et al., 2021).

The inhibitive properties of *Musa acuminata Colla* are highlighted in this study. The weight loss technique was used to investigate the corrosion behavior of mild steel and to assess the inhibition efficiency of native banana (*Musaa cuminate colla*) extract in 1M $H_2SO_4$ at various temperature ranges and inhibitor concentrations. Some thermodynamic parameters were also investigated in order to gain a better understanding of the effect of inhibitor structure using weight loss measurements.

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## 2. Materials and Methods

### 2.1 Study Plant (*musa acuminata colla*)

**Figure 1**: Image of Native Banana

## 3. Preparation of the Sample and Reagents

Native banana (musa cuminate colla) samples were meticulously collected from local farmers in Amassoma Town, Southern Ijaw Local Government Area, Bayelsa State. The samples were washed with tap water and air dried for 72 hours. The samples were then oven dried at 105° C for two days before being ground into powder. 100 g of the powder was placed in a flask with a flat bottom and 1000 ml of ethanol and left for 72 hours before being thoroughly filtered. The stock solution was made from the filtrate, which was vaporized and then used to make solutions containing (0.2, 0.4, and 0.6) g/L of the green inhibitor. To make a 1M solution of $H_2SO_4$, 54.35 mL of concentrated $H_2SO_4$ was diluted with 1000mL of distilled water. All of the reagents used are of analytical quality. All glass products used were cleaned with a liquid cleaning agent and washed three times before being dried in the oven.

## 4. Weight Loss Measurements

The weight loss measurements were carried out exactly as described previously (ASTM, 2004; Manickam et al 2016: Royani et al., 2019). For weight-loss experiments, the mild steel was mechanically press-cut into 5cm x 4cm measurements. Prior to use, the coupons were ground with various grades of silicon carbide paper, degreased in ethanol, air dried, and stored in a moisture-free desiccator. In a controlled environment, weighed specimens were immersed in acid medium with and without inhibitors for specified immersion times (2, 4, 6, 8, and 10 hours) and temperatures (303.15, 313.15, 323.15, 333.15, 343.15 K). Following the experiment, the specimens were removed from the acid medium and cleaned with water, acetone, air dried, and weighed. Using equation 1, 2 and 3, the corrosion rate, inhibition efficiency and surface coverage were calculated using the mean weight-loss values. Using the formula, the corrosion rate in millimeters per year was calculated (Govindasamy and Ayappan., 2015).

$$\text{Corrosion rate(mmpy)CR} = \frac{87.63 \text{ X Weight loss(mg)}}{\text{Density}\left(\frac{g}{cm3}\right) \text{x Area(cm2) x Time(hrs)}} \quad (1)$$

1mpy=0.0254mmpy

Where:

W = Weight loss = Initial weight ($W_1$) – Final weight ($W_2$) in milligrams;

A = Total surface area of specimen in cm2;

T = Total time sample was immersed in hours;

D =Density of the specimen in g/cm3;

CR = Corrosion rate in millimeters per year.

### 4.1 Evaluation of Efficiency of Inhibitor Inhibitor Efficiency Has Been Determined by Using The Following Relationship

$$\text{IE\%} = \frac{\text{Wo} - \text{Wi}}{\text{Wi}} \quad (2)$$

Where Wo is the weight loss without inhibitor and Wi is the weight loss with inhibitor.

## 5. Evaluation of Surface Coverage (θ)

$$\text{Surface coverage} = \frac{\text{Wo} - \text{Wi}}{\text{Wo}} \quad (3)$$

Where Wo and Wi are the weight losses per unit time without and with inhibitor respectively.

## 6. Adsorption Isotherms

A graph was drawn between C/ Vs C or C/ Vs Log C to determine whether inhibitor adsorption follows Temkin's / Langmuir isotherm to obtain a linear relationship (Govindasamy and Ayappan, 2015). To determine and select the best fit isotherm, the correlation co-efficient ($R^2$) values were used.

## 7. Results and Discussion

The inhibition efficiency and corrosion rate values obtained from weight loss measurements of mild steel for different concentrations of native banana (musa acuminate colla) in 1M $H_2SO_4$ at temperature ranges of 303.15–343.15K and for various immersion periods: 2, 4, 6, 8, and 10 hours are presented in (Table 1-2). Figures 2-6 show graphical representations of the variation in inhibitor efficiencies.

The results showed that as the inhibitor concentration increased, so did the inhibition efficiency.

In this study, the optimum inhibitor concentration required to achieve efficiency was determined to be 0.20 g/L (IE percent = 90%). Adsorption on the metal surface can explain why native banana (musa acuminate colla) inhibits mild steel corrosion.

**Table 1**: shows the inhibition efficiency of different inhibitor concentrations

| Temp. K | Inhibitor Conc (mg/L) | Weight Loss (mg) | Inhibitor Efficiency | Corrosion Rate (mmpy) | Surface Coverage (θ) |
|---|---|---|---|---|---|
| 303.15 | Blank | 0.5 | - | 0.0279 | |
| | 0.2 | 0.4 | 25 | 0.0223 | 0.200 |
| | 0.4 | 0.4 | 25 | 0.0223 | 0.200 |
| | 0.6 | 0.3 | 66.67 | 0.0167 | 0.400 |
| | | | | | |
| 313.15 | Blank | 0.5 | - | 0.0278 | - |
| | 0.2 | 0.5 | - | 0.0278 | - |
| | 0.4 | 0.4 | 25 | 0.0223 | 0.200 |
| | 0.6 | 0.4 | 25 | 0.0223 | 0.200 |
| | | | | | |
| 323.15 | Blank | 0.7 | - | 0.0390 | |
| | 0.2 | 0.6 | 16.67 | 0.0334 | 0.1428 |
| | 0.4 | 0.6 | 16.67 | 0.0334 | 0.1428 |
| | 0.6 | 0.5 | 40 | 0.0278 | 0.2857 |
| | | | | | |
| 333.15 | Blank | 1.7 | - | 0.09476 | |
| | 0.2 | 1.6 | 0.625 | 0.08919 | 0.0588 |
| | 0.4 | 1.5 | 13.33 | 0.083616 | 0.1176 |
| | 0.6 | 1.1 | 54.45 | 0.061318 | 0.3529 |
| | | | | | |
| 343.15 | Blank | 1.9 | - | 0.1059 | |
| | 0.2 | 1.0 | 90 | 0.04459 | 0.5789 |
| | 0.4 | 1.4 | 35.71 | 0.07804 | 0.2635 |
| | 0.6 | 1.6 | 18.75 | 0.08919 | 0.1579 |

**Table 2**: Inhibition efficiencies of 0.6g/L concentrations

| Temp. K | Inhibitor Conc | Weight Loss | Inhibitor Efficiency | Corrosion Rate |
|---|---|---|---|---|
| 303.15 | | | | |
| | Blank | 0.5 | | 0.0279 |
| | 0.6 | 0.3 | 66.67 | 0.0167 |
| 313.15 | Blank | 0.5 | | 0.0279 |
| | 0.6 | 0.4 | 25 | 0.0223 |
| 323.15 | Blank | 0.7 | | 0.0390 |
| | 0.6 | 0.5 | 40 | 0.0279 |
| | | | | |
| 333.15 | Blank | 1.7 | | 0.0948 |
| | 0.6 | 1.1 | 54.55 | 0.0613 |
| 343.15 | Blank | 1.9 | | 0.1059 |
| | 0.6 | 1.6 | 18.75 | 0.0892 |
| | | | | |

The surface coverage (θ) was calculated for various inhibitor concentrations. A plot of C/ θ versus C yields a straight line, confirming that the inhibitor, native banana (musa acuminate colla), followed the Langmuir adsorption isotherm.

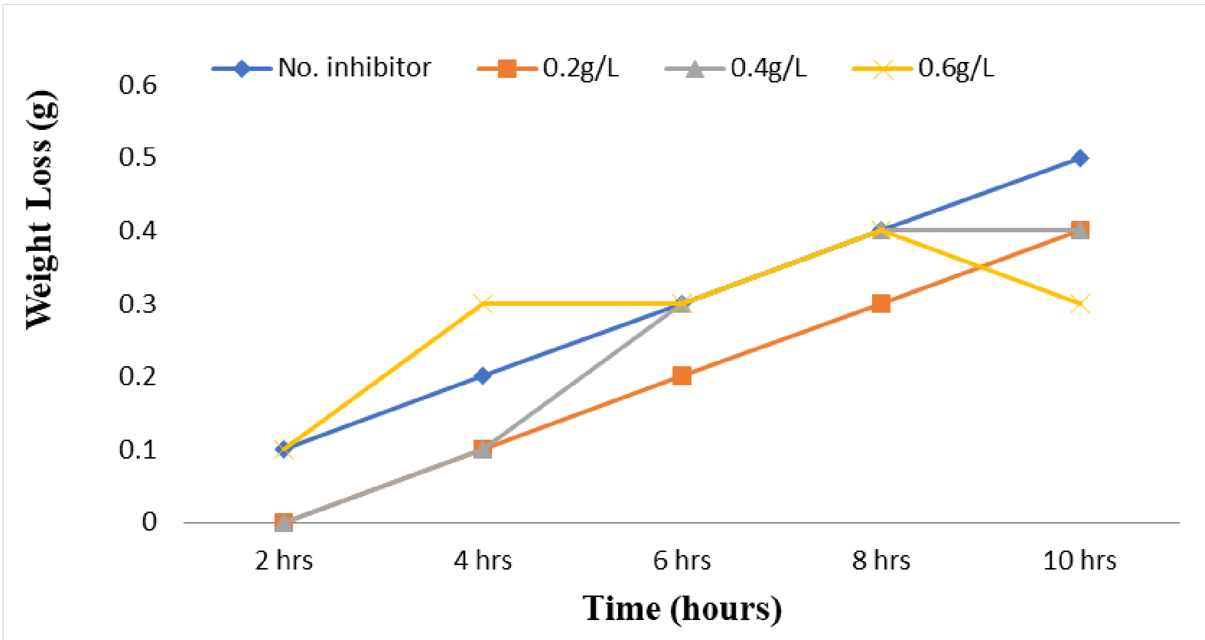


**Figure 2**: Variation of weight loss (g) of mild steel at 303.15K

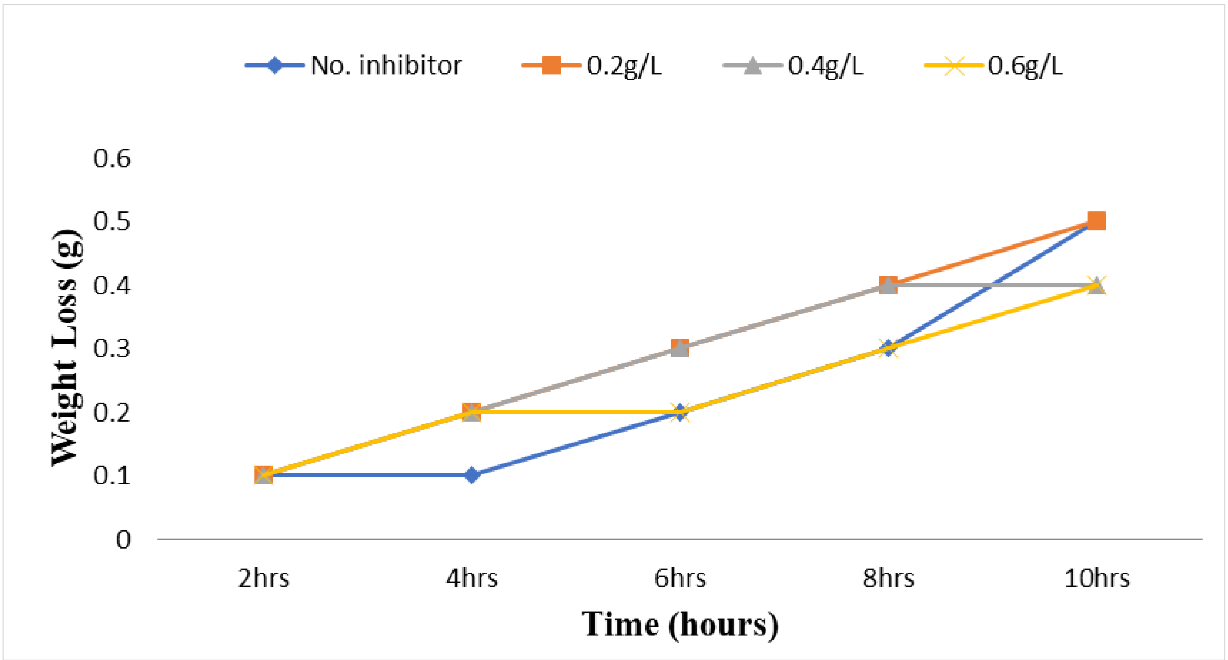


**Figure 3:** Variation of weight loss (g) of mild steel at 313.15K

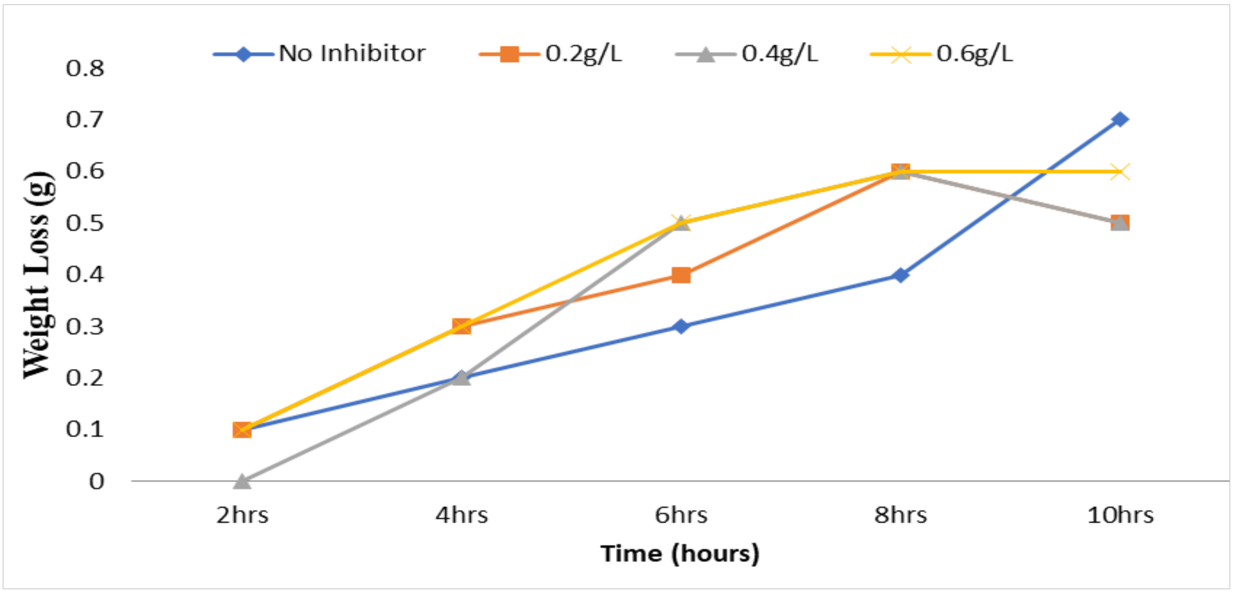


**Figure 4:** Variation of weight loss (g) of mild steel at 323.15K

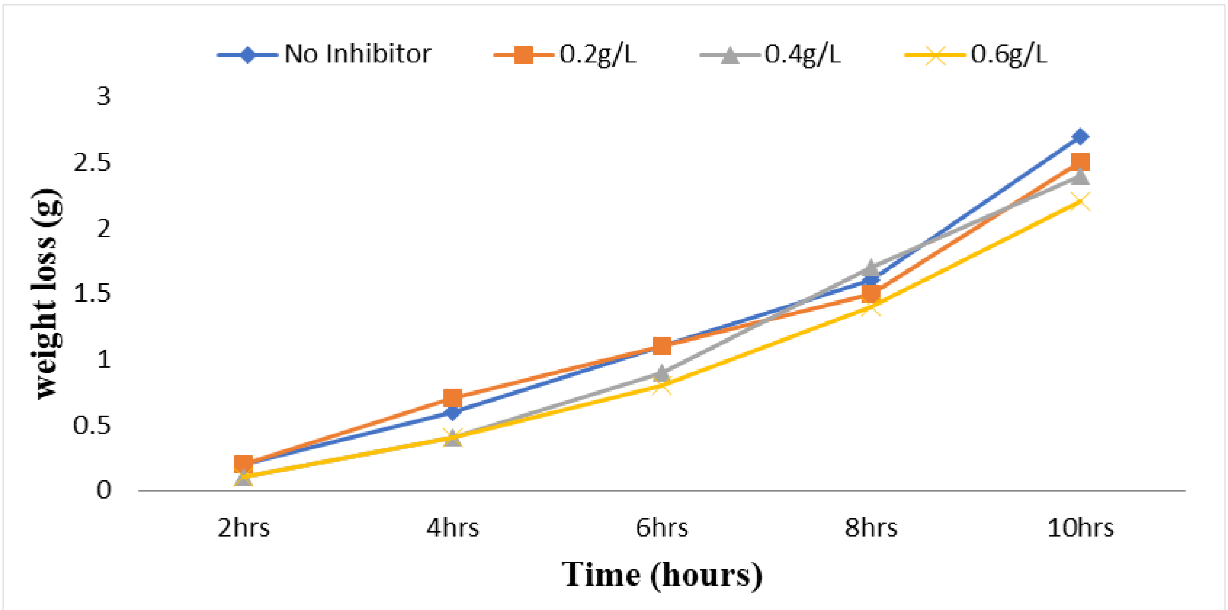


**Figure 5**: Variation of weight loss (g) of mild steel at 333.15K

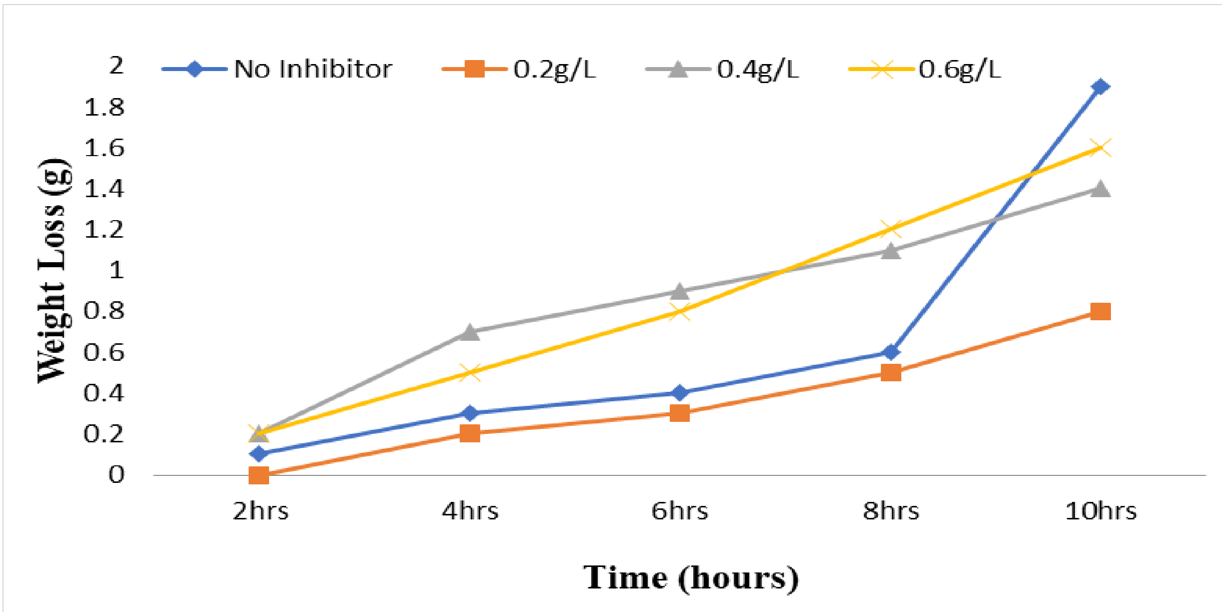


**Figure 6**: Variation of weight loss (g) of mild steel at 343.15K.

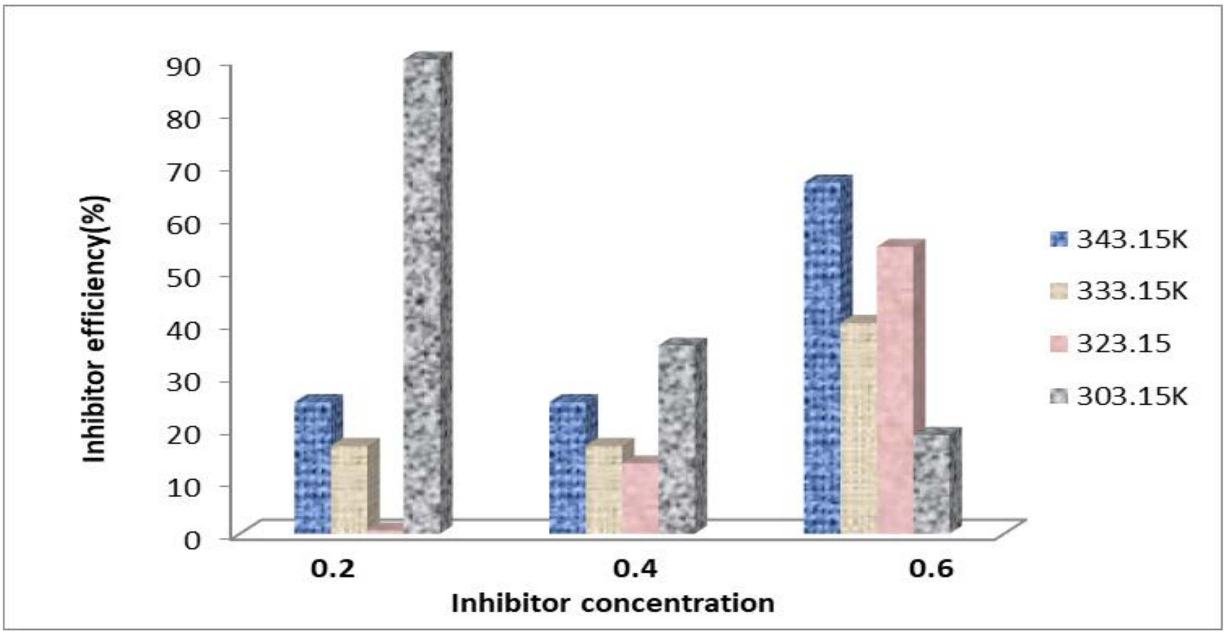


**Figure 7**: Plot of Inhibitor efficiency (%) Vs Inhibitor concentration (g/L)

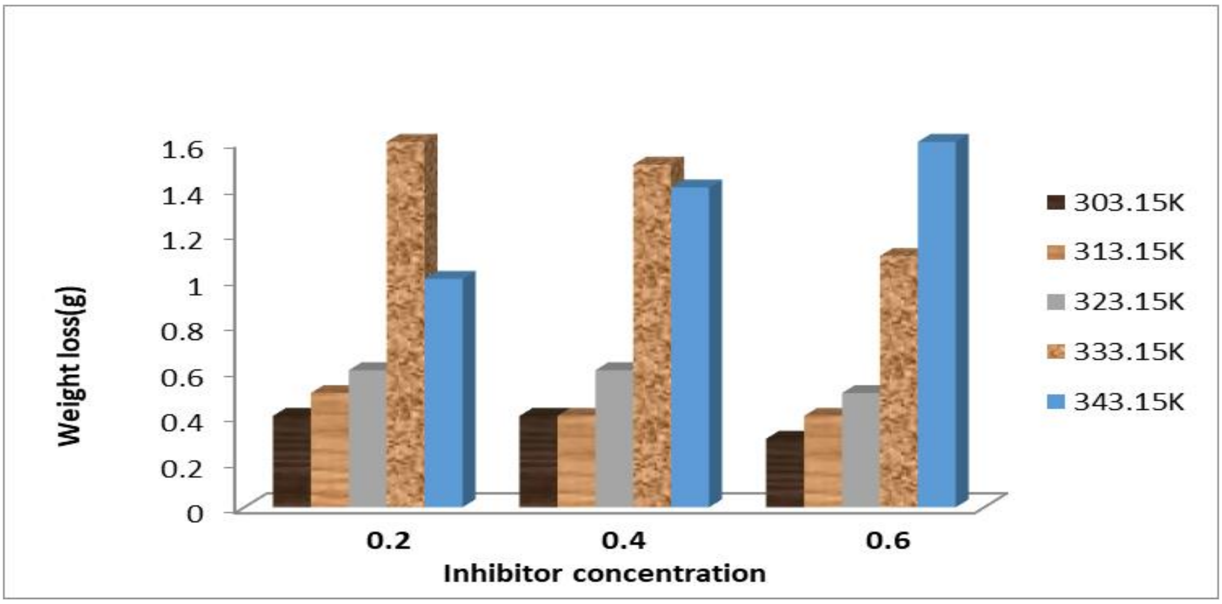


**Figure 8:** Plot of Weight loss (g) Vs Inhibitor concentration (g/L)

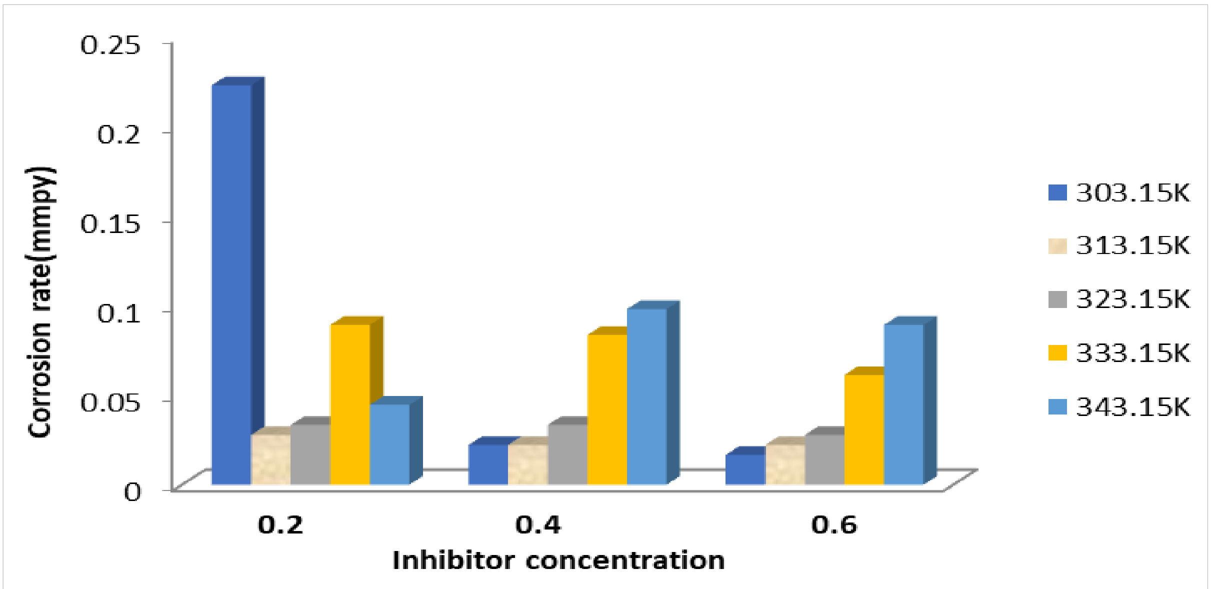


**Figure 9**: Plot of Corrosion rate(mmpy) Vs Inhibitor concentration (g/L)

According to the findings, corrosion rate decreases as inhibitor concentration increases; surface area increases as inhibitor concentration increases; inhibition efficiency increases as extract concentration increases; and corrosion rate decreases as temperature increases. The native banana (musa acuminate colla) was adsorbed on the metal surface, protecting it from the corrodent's action. This suggests that plant extracts reduce the corrosion of mild steel in 1 M $H_2SO_4$ solutions, and that the extent of corrosion inhibition is proportional to the amount of extract present. The plant's best inhibition efficiency was 90% at 0.2 g/L of extract at 343. 15K. Because the rate of corrosion was significantly slowed in the presence of the inhibitor, an extract of native banana (musa acuminate colla) may be a good inhibitor. The adsorption of phytochemicals present in the plant on the metal surface is thought to occur via the basic hetero atoms present in the phytochemicals' molecular structure. This is consistent with previous reports by, (Ikeuba et al., 2015; Okafor et al., 2004).

Metal ions move into solution at active areas (the anode) and transfer electrons from the metal to an acceptor at less active areas (the cathode); the cathodic process requires the presence of an electron acceptor such as oxygen, oxidizing agents, or hydrogen ions. Corrosion can be reduced by slowing or stopping the anodic or cathodic reactions, or both. Inhibitors form a protective barrier on the metal surface and interact with anodic and/or cathodic reaction sites to reduce oxidation and/or corrosive reactions (Singh et al., 2016).

In corrosive media, there are several common cathodic reactions:

$$2H^+ + 2e^- \rightarrow H_2 \quad (4)$$

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \quad (5)$$

The reduction reaction results in the evolution of hydrogen gas as follows:

$$2H^+ + 2e^- \rightarrow H_{ads} \rightarrow 2H_2 \quad (6)$$

In eq. (3), hydrogen ions adsorbed on the metal surface are catalyzed in combination with other hydrogen ions held hidden, resulting in evolved hydrogen gas on the cathode surface; the amount of hydrogen bubble in the presence of an inhibitor refers to the inhibitor's ability to prevent this reaction and protect the metal from corrosion (Oguzie, 2005). The action of inhibitor molecules is caused by their adsorption on an exposed metal surface as neutral molecules rather than hydrogen ions adsorbed from the metal surface.

$$\text{Inhibitor} + nH_{ads} \rightarrow \text{Inhibitor}_{ads} + H_2 \quad (7)$$

A general mechanism for mild steel dissolution in acid solutions would be similar to that reported by (Omnia et al., 2018; Singh et al., 2016; Oguzie et al., 2005) . Temperature is an important factor that influences the corrosion of metallic materials. The effect of temperature on mild steel corrosion in 1 M $H_2SO_4$ solution in the absence and presence of inhibitor was studied at temperatures ranging from 303.15 to 343.15 K. The efficiency of the inhibitor decreases as the temperature rises. According to other authors, this behavior is primarily caused by the desorption of inhibitor molecules, which may result in a reduction in the inhibitor capacity to be adsorbed on the metallic surface at elevated temperatures (Chadili et al., 2021; Hassan et al., 2007; Bhajiwala and Vashi, 2001; menaka, 2016; Deyab et al., 2015). As the temperature rose, so did the metal's dissolution. This observation is attributed to the general rule governing the rate of chemical reaction, which states that the rate of chemical reaction increases as temperature rises. Also, increasing the temperature promotes the formation of activated molecules, which can be doubled with a temperature increase of 283.15K, increasing the reaction rate. This is due to the reactant molecules gaining more energy and being able to overcome the energy barrier faster (Ita and Offiong, 1997). Temperature increases may also increase the solubility of protective films on metals, increasing the metal's susceptibility to corrosion (Okafor et al., 2004). The solubility of oxygen gas decreases as temperature rises. As a result, oxygen concentration is expected to be higher at higher temperatures, which in this case may be 343.15 K. The presence of a high concentration of oxygen causes the metal to corrode more quickly. Solubility of solids generally increases with increasing temperature. This explains why the solid protective film becomes more soluble as the temperature rises (Nathaniel et al., 2020).

## 8. Adsorption Isotherm

It is well understood that the main process influencing the corrosion rate of metals is inhibitor adsorption. Inhibition adsorption can influence corrosion rate in two ways. In the first case, inhibitors reduce the available reaction area by adsorption on the metal, which is referred to as the geometric blocking effect. In the second way, inhibitors change the activation energy of the cathodic and/or anodic reactions that occur in the inhibitor-free metal during the inhibited corrosion process, which is known as the energy effect (Hmamou et al., 2012; Al-otaibi., 2014). The surface coverage (θ) for various inhibitor concentrations was calculated. The observation of this study in a plot of C/θ Vs C gives a straight line ($R^2$ = 0.923), which may suggest that the inhibitor obeyed the Langmuir adsorption isotherm. The formation of an inhibitor-adsorbed layer on the active sites of the metal surface results in the greatest inhibition (Govindasamy and Ayappan., 2015).

## 9. Conclusion

This study discovered that a native banana extract *(Musa acuminate colla*) inhibits corrosion in a 1M $H_2SO_4$ acid solution. This plant extracts act as a good green mild steel inhibitor in acidic medium and can be used to retard mild steel corrosion rate if the appropriate concentration is used. At higher temperatures, there is a progressive increase in weight loss, indicating that the dissolution of the metal increases. The inhibitor's adsorption on the mild steel surface follows the Langmuir adsorption isotherm ($R^2$ = 0.923) and compares favorably to many documented green inhibitors. As a result, ethanol extracts of native banana (*Musa acuminate colla*) may be considered a good corrosion inhibitor; the rate of corrosion is significantly reduced in the presence of the inhibitor.

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