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## CORROSION INHIBITION STUDY OF *Cratevaadansonii* PLANT EXTRACT ON MILD STEEL IN ACIDIC MEDIA

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### ABSTRACT

A study on the inhibitive properties of *Cratevaadansonii* plant extracts on mild steel in 1.75 M HCl was embarked upon in this research using gasometric and potentiodynamic polarization technique at room temperature. The mild steel coupons were immersed in blank of 1.75 M HCl and the procedure repeated for the various extract concentrations of 10% - 50% v/v. The amount of hydrogen gas evolved due to the reaction between acidic extract and the mild steel coupons were evaluated. The observed inhibition efficiency using gasometric method indicated a direct relationship with increase in concentration of the inhibitors up to 50% concentration for both extracts. A similar trend was observed in the Tafel plot using the polarization technique. The adsorption study revealed the use of *Cratevaadansonii* extract obeyed the Freundlich isotherm which characterizes physisorption. The use of *Cratevaadansonii* extract is hereby proposed as a suitable inhibitor for the corrosion of mild steel in acidic media.

Keyword: Gasometric, Freundlich isotherm, Coupons, physisorption

### 1. Introduction

Corrosion is said to occur when a metal depreciates by being chemically attacked by its immediate surroundings[1]. It is also a process of taking metals back to its original state which is from its mineral ore obtained naturally. Corrosion has been a continuous problem and has not been able to be eliminated completely. It has been discovered that over one-fifth of steel and iron which are



produced yearly are used to replace rusted metal. Inhibitors are used to reduce the rate at which a metal will corrode by interfering with the chemical reaction that will take place [2].

Inhibitors are substances which when added in small quantity to a material retards or slows down the rate of corrosion whether a metal or alloy. The selection of a certain corrosion inhibitor depends on factors such as the type of corrosive environment (acidic or basic), its concentration, velocity of flow of fluid, the presence of dissolved inorganic or organic material and the nature of the metal being exposed to corrosion[2,3]. Several corrosion inhibitors have been used to prevent corroding of metal surfaces but the use of green corrosion inhibitor is the one of the best methods for corrosion protection because of its low cost and method of practice [4,5]. In the past, inhibitors had been accepted greatly by industries because of their excellent anti corrosive properties. Sadly, many of the inhibitors showed to have secondary effects in damaging the environment. Now scientists are beginning to search for eco-friendly inhibitors such as green inhibitors. Inhibition of corrosion is as a result of adsorption on the surface of the metal (chemisorption) and a protective thin film is formed with the inhibitor effect or combination of a metallic surface and an inhibitor ion. There are various ways for preventing corrosion but the use of green inhibitors is the cheapest and most readily available method [6,7]. Various studies have confirmed the use of plant based extract as corrosion inhibitors in acidic medium [8,9]. *Azadirachtaindica* inhibitory action was successful on mild steel as reported by [10] and also successful on aluminium as reported by [11]. The aim of this research work is to study the inhibitive property and adsorption behavior of *Cratevaadansonii* plant extract Mild steel in acidic media

### **1.1 *Cratevaadansonii* Plant**

*Cratevaadansonii* is known to be a sacred garlic pea or temple plant (English) [12]. It is a deciduous plant tree which develops a large crown as it goes older. It can be found in galleried forest, savannah woodland and old termite mounds. They are often found in river banks in the east Africa and riverine or swamp forest, forest edges in southern Africa. It can be called ungodudu (Hausa, Northern Nigeria), eegunorun or ajanaka (Yoruba, western Nigeria), and amakarode (Igbo, eastern Nigeria). It can be found mostly in Japan, South Asia, Australia, and several south pacific islands. It is said that the leaves are applied to the head as a mild counter-

irritant for easing headaches. The phytochemical study shows that *Cratevaadansonii* manifests flavonoids, saponins, alkaloids, trepenoids and cardiac glycosides [13].

## **2. Materials and Methods**

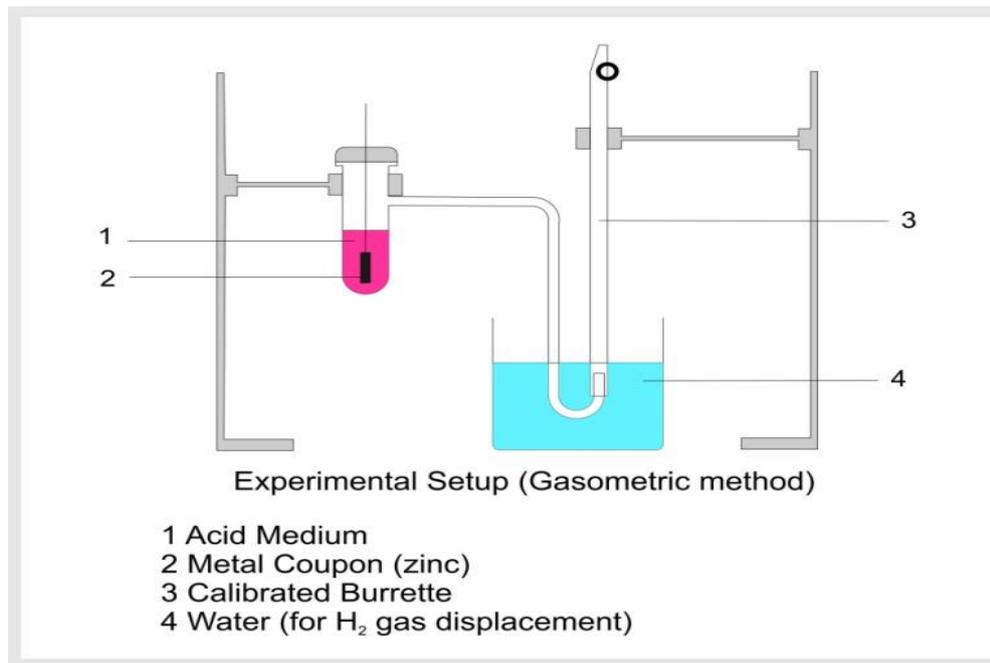
### **2.1 Sample Preparation**

Mild steel coupons of dimensions 15mm x 8.5mm were employed as specimen for this particular study. Each of the coupons was examined carefully to detect any rough edge and may influence the monitoring process, washed with ethanol and dried with acetone.

The leaf of *Cratevaadansonii* were collected and then air dried in the laboratory. The leaves were then soaked in 40ml of methanol to get the methanolic extract. Then 2g of the methanolic extract was weighed in a beaker the stock solution was collected. 200 ml of the acid (1.75 M of HCl) was added to dilute the extracts because of their thick nature. This was then prepared into different concentrations (10%, 20%, 30%, 40% and 50%) volume/volume (v/v) using serial dilution.

### **2.2 Gasometric measurement**

The gasometric technique which is also called (gas-volume technique) is a technique which gives speedy and dependable way of getting any perturbation by the inhibition with regards to the evolution of gas at the corroding interface [3,11](Figure 1). Correlation between the gasometric method and other methods of corrosion monitoring have been reported [11,14,15]. Each of mild steel in coupons were dropped into the mylius cell containing 40 ml of the blank solution (1.75 M HCl). The 1.75 M HCl as the control and also the presence of the extract (*Cratevaadansonii*) in different concentrations (10% – 50%) at room temperature which lies on the principle of the given off hydrogen gas due to reaction of HCl with mild steel. The volume of hydrogen gas evolved per minute interval was recorded in the different concentrations.



**Fig.1:** Experimental set-up for gasometric technique

Source: Ajanaku *et al.*, (2015)

The inhibitor efficiency and surface coverage was determined using equation 1 and 2 respectively as proposed by [16,17]

$$IE(\%) = \frac{V_H - V_{HI}}{V_H} \times 100 \quad (1)$$

$V_H$  = Volume of hydrogen gas evolved without inhibitor

$V_{HI}$  = Volume of hydrogen gas evolved with inhibitor

To get the surface coverage which  $\theta$

$$\theta = \frac{IE}{100} \quad (2)$$

### 2.3 Linear polarization measurement

The potentiodynamic polarization technique helps determine the corrosion of a metal by observing the response of the charge transfer to a controlled electrochemical disturbance. A polarization scan allows for the extrapolation of corrosion parameters of the surface of a metal.

This method involves the change in potential of the working electrode while observing current produced as a function of time or potential. When this scanning is ongoing the oxidation or reduction of an electron-active specie can be limited by the reactants and products movements and transfer of charges. This employs as a three-electrode configuration.

The potentiodynamic polarization technique was done using an electrochemical work station. The solution used for the measurement was 1.75 M HCl. The corrosion inhibition efficiency  $\eta_p$  (%) was calculated from the measured corrosion current density ( $I_{corr}$ ) based on the assumption from this literature[2]. The relationship is given in equation 3.

$$\eta_p(\%) = \frac{I_o corr - I_i corr}{I_o corr} \times 100 \quad (3)$$

$I_o corr$

$I_o corr$ -current density without inhibitor

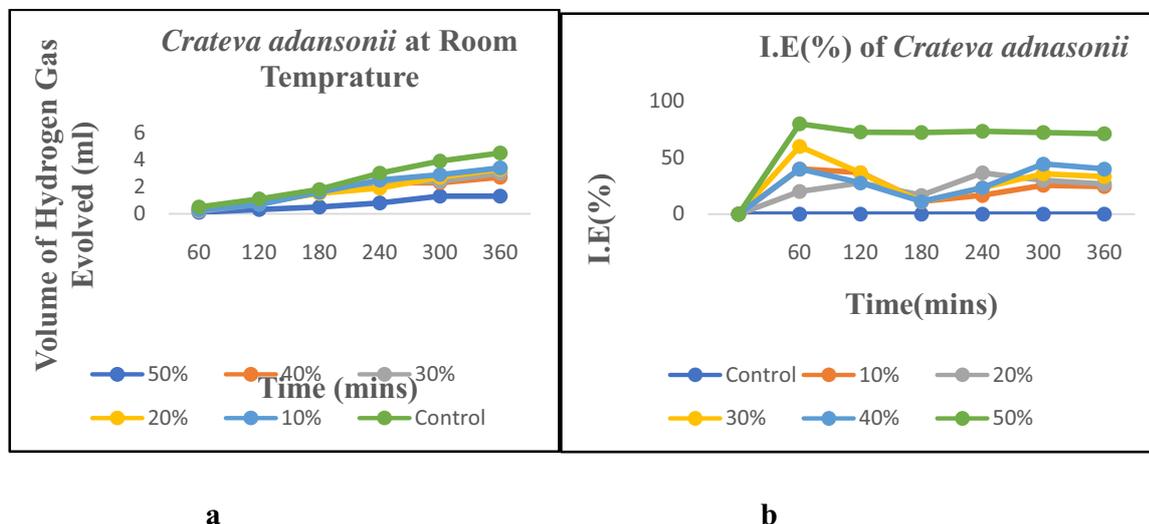
$I_i corr$ - current density with inhibitor

## 2.4 Adsorption studies

Corrosion inhibition mechanism using natural products is the adsorption of the inhibitor of the surface of a metal or an alloy which causes obstruction of the active sites and decreases the rate at which the metal or alloyed will corrode. This adsorption study gives us the information of the molecules been adsorbed as well as the metal surface. We have two types of interaction that helps explain the adsorption of natural products which are chemisorption (chemical adsorption) and physisorption (physical adsorption). In study of adsorption isotherms, the degree of surface coverage is important. The values of the surface coverage for *Crateva adansonii* was obtained from the gasometric measurement. The Temkin, Freundlich, Langmuir and Frumkin isotherms and the correlation coefficient ( $R^2$ ) are applied to determine the best fitted isotherm.

### 3. Results and Discussion

#### 3.1 Gasometric Measurement



**Fig. 2(a)** Variation of hydrogen gas evolved (ml) against time (mins) for *Crateva adansonii* (b) inhibition efficiency (%) against time for *Crateva adansonii* extract on Mild steel at different concentrations in 1.75 M HCl.

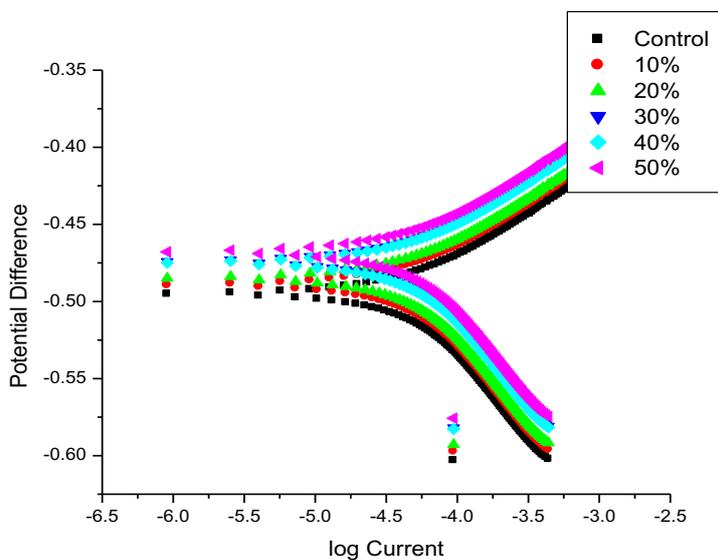
In the corrosion study of mild steel in 1.75 M HCl there was fast evolution of hydrogen gas in the presence of the blank solution (0% extract) but with the presence of the extract in the acidic media, the volume of hydrogen gas released decreased. The volume of gas evolved decreased with increasing extract concentration. The decrease of hydrogen gas evolved continued at 20%; 30%; 40%; and 50%. As shown in Fig. 2a, the 50% concentration has the lowest amount of hydrogen gas evolved. This shows that the action of the inhibitors is dependent on concentration, this shows close resemblance with inhibitive behavior of conventional organic inhibitors [18,19]

From Fig. 2b, it showed that 50% concentration has the highest inhibition efficiency in 1.75 M HCl. The inhibition efficiency of the plant extract increases as concentration increases. 50% concentration had the highest inhibition efficiency then 40%; 30%; 20% and 10% which had the lowest inhibition efficiency. This is in resemblance with what was observed by [20] on *sidaacuta* as an inhibitor for mild steel in  $H_2SO_4$  media

### 3.2 Linear polarization measurement

Corrosion inhibition study of *Cratevaadansonii* leaves extract on mild steel at room temperature in 1.75 M HCl was evaluated with the use of Tafel plot and the results were in the form of curves shown in Figure 3. The parameters which were obtained from this curve were Corrosion current density ( $I_{corr}$ ), Corrosion potential ( $E_{corr}$ ), cathodic and anodic Tafel slopes. Also from the Tafel plot it showed that the current potential values moved more to the positive values with the increase in concentration of the extract. As potential difference increases current also increases. From the cathodic and anodic current density decreased with increase in concentration of the inhibitor [21]. Inhibitors can be classified based on three types which are cathodic, anodic or mixed inhibitors. If the  $E_{corr}$  of an inhibitor changes to more than 0.85 mV, this can be said to be either an anodic or a cathodic type. Another reason for it being a mixed inhibitor is because the anodic and cathodic regions are of the same length, one was not longer than the other from the Tafel plot. The 50% concentration has the best inhibitive effect on mild steel in 1.75 M HCl because it moved the most to the positive region in the Tafel plot.

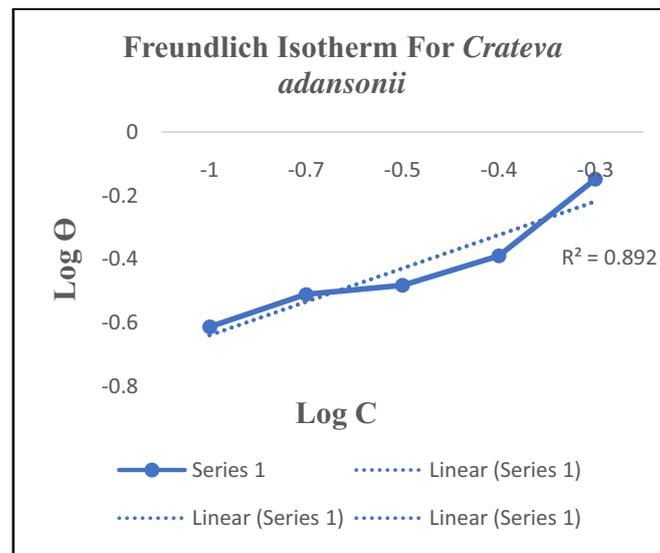
From Fig. 3. *Cratevaadansonii*, Tafel plot showed that the blank was closer to the inhibitor at different concentrations 50%; 40%; 30%; 20% and 10%, which showed that it has little inhibitive property on mild steel in 1.75 M HCl at room temperature. The 50% concentration was the best because its potential difference value moved most to the positive region in Tafel plot. The Tafel plot also indicates that the extract is a mixed type of inhibitor because the  $E_{corr}$  value did not exceed 0.85V and also the length for both the anodic and cathodic regions are of the same, one was not longer than the other. The current potential values moved more to the positive values with the increase in concentration of the extract. As potential difference increases current also increases[2].



**Fig. 3:** The Tafel plot for *Crateva adansonii* extract using potentiodynamic polarization technique on Mild steel at different concentrations in 1.75 M HCl at room temperature

### 3.3 Adsorption Isotherms

The extracts of *Crateva adansonii* at room temperature were subjected to adsorption isotherms namely Langmuir, Freundlich, Temkin and Frumkin adsorption isotherm. The data for *Crateva adansonii* extract fits best into the Freundlich isotherm ( $R^2 = 0.8924$ ) which characterizes physisorption as shown in Fig. 4. It forms a unilayer that occurs due to weak van der Waals force of attraction. The adsorption studies clearly indicated that the experimental data fitted closely to Freundlich which suggests that the corrosion inhibition by inhibitor compounds is being a result of their adsorption on the metal surface [3, 10, 17].



**Fig. 4:** Graph showing Freundlich adsorption isotherm of *Crateva adansonii* extract at different concentrations on Mild steel in 1.75 M HCl at room temperature

#### 4. Conclusion

The result from this research work shows that the plant extracts of *Crateva adansonii* acted as a very good inhibitor on Mild steel corrosion in 1.75M HCl. The corrosion inhibition efficiency increased with increase in concentration of the plant extracts which deduces that the inhibitive properties of the plants extracts are concentration dependent. The highest inhibition efficiency for *Crateva adansonii* was 50% from the polarization result while that of gasometric result shows *Crateva adansonii* highest inhibition efficiency was at 50% concentration. From the Tafel plots, the potential difference increases with concentration of the extracts. The *Crateva adansonii* leave extract obeyed Freundlich adsorption which is an indication of physisorption. The findings from this work proposed an alternative natural source of corrosion inhibitor for preventing the corrosion of mild steel.

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