Corrosion Inhibitory properties of *Biden pilosa* Plant Extract on Mild Steel in Acidic Media

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Abstract
A study on the inhibitive properties of *Biden pilosa* 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 dipped in 1.75 M HCl blank and altered concentration of *Biden pilosa* plant extract (10%; 20%; 30%; 40% and 50% v/v). The rate of reaction between the acidic extract and the mild steel coupons gives the volume of hydrogen gas given off during the reaction. The observed inhibition efficiency using gasometric method indicated a direct relationship with upsurge in concentration of the inhibitors up to 50% concentration for *Biden pilosa* extracts. A comparable trend was observed in the Tafel plot using the polarization technique. The adsorption study revealed the use of *Biden pilosa* extract followed the Langmuir isotherm principles (chemisorption). The use of *Biden pilosa* extract is hereby proposed as good inhibitors for mild steel corrosion at 1.75 M HCl environment.

Keywords: Corrosion, *Biden pilosa* extract, Mild steel.

1. Introduction
The numerous use of mild steel in different industries for fabrications of wires, nails, automobiles, fences, pipes, reaction vessels is due to its availability, exceptional metal properties and low cost [1, 2]. The ductility and wield ability is attributed to its low carbon content which implies that effect of heating and quenching will not affect the strength and hardness it. Mild steel is also high in iron and ferrite which makes it magnetic [2]. Corrosion is the deterioration of a metal and it can be described as an irreversible reaction which involves the reversion of metals back to its original state, that is, the mineral ore from which it is obtained naturally [3]. When a metal such as steel comes in contact with its environment, a reddish brown coloration is observed on the exterior of the metal and this occurs over a short period of time. The reddish brown colour indicates the formation of rust and this points to the start of corrosion [4].

The prevention of corrosion is a foremost problem for many companies all over the world and this has been attributed to the high cost of maintaining metals especially in the oil and gas sector. There are different methods been used such as painting, coating and galvanizing; but, all these solutions are relatively expensive and causes harmful effect to the environment. Inhibition is a very good method to reduce the rate of corrosion. Inhibitors has been accepted greatly by industries because of their excellent anti corrosive properties. Sadly, some inhibitors showed to have secondary effects in environmental damage. The use of green corrosion inhibitor poses as the best and safest methods for corrosion protection because of its low cost and method of practice [5, 6].

Green corrosion inhibitors are substances that are slowly broken down by natural processes and does not contain dangerous compounds. They are environmentally friendly and are readily available. Due to biodegradability and purity of plant extract, they are the best inhibitors. This plant extracts can be obtained by using cheap solvents that have very low toxicity at very low cost. Aqueous extract is better but its solubility is low to many natural products so ethanol extract is used [7].
There are a lot of researches published on green corrosion inhibitors such as the use of Africa bread fruit [8]; *Occimum viridis*, *Hibiscus sabdariffa*, *Telferia occidentalis*, and *Azadirachta indica* leaves extracts [8]; *Pennisetum purpureum* extract [5]; *Ficus hispida* extracts [9]; *Tagetes erecta* extract [10]; *Tripleurospermum auriculatum*, *Anvillea garcinii*, *Lycium shawii*, *Cassia italic*, *Teucrium oliverianum*, *Ochradenus baccatus* and *Carthamus tinctorius* leaf extracts [11].

Other plant-based inhibitors that were previously investigated and reported include *Murraya koenigii* leaves, *Vernonia amygdalina*, water hyacinth, *Jatropha curcas*, *Nicotiana tabacum*, *Aquilariacrasna*, *Psidium guajava* and *Cucurbita maxima* [6]. It is worth mentioning that most of the aforementioned green inhibitors among several other inhibitors are extracts from unwanted plants (weed). This means that the challenges associated with sustainable production of these inhibitors on a commercial scale has been solved to a greater extent. Therefore, the search for different sources of green (plant based) inhibitors would continue to attract the interest of researchers [5].

*Bidens pilosa* is an Asteraceae plant and a flowering plant that as contributed to medicinal species worldwide. It has been used as a traditional medicine in the treatment of diabetes, influenza and gastroenteritis [12]. Their leaves, roots are said to possess anti-bacterial, anti-malaria, anti-microbial, hepa-protective and hypertensive activities [13]. It is used for the treatment of foot and mouth disease, hepatitis, menstrual disorder, diabetes, angina, pharyngitis, laryngitis, hemorrhoids, gargle for mouth blisters, sores, stomach upset, sore throat, food poisoning, laceration and water retention. Phytochemical screening shows that *Bidens pilosa* leaves has secondary metabolites such as terpenoids, phlobatannins, flavonoids, tannins and cardiac glycoside imbedded in it [14]. The aim of this research work is to know the effect of *Bidens pilosa* on the corrosion of Mild steel in 1.75 M HCl environment.

2. Methodology

2.1 Preparation of specimen

The mild steel specimen was hard pressed into coupons of 15mm x 8.5mm with use of a manual edge metal cutter. 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.

2.2 Sample Preparation

*Bidens pilosa* leaves were collected and then air dried in the laboratory. The leaves were then soaked in 40 ml 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 using 1.75 M HCl for further use in order to study the inhibitive abilities of the extract.

2.3 Gasometric measurement

Each of mild steel in coupons were plunged into the mylius cell which contains 40 ml of the blank solution (1.75 M HCl). The 1.75 M HCl as the control and also the presence of the extracts (*Bidens pilosa*) 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.

The inhibitor efficiency can be calculated using this formula:

\[
I.E(\%) = \frac{V_H - V_{HI}}{V_H} \times 100
\]

\[V_H = \text{Volume of hydrogen gas evolved without inhibitor}\]
\[ V_{HI} = \text{Volume of hydrogen gas evolved with inhibitor} \]

To get the surface coverage which—

\[ \theta = \frac{IE}{100} \]

### 2.4 Potentiodynamic polarization technique

The potentiodynamic polarization technique was done using an electrochemical work station. The corrosion inhibition efficiency \( \eta \) (%) was evaluated using the equation below.

\[ \eta(\%) = \frac{I_{ocorr} - I_{icorr}}{I_{ocorr}} \times 100 \]

Where \( I_{ocorr} \) is the corrosion density of the instrument in the absence of \textit{Biden pilosa} inhibitors while \( I_{icorr} \) is the corrosion current density of the instrument in the presence of \textit{Biden pilosa} inhibitors.

### 2.5 Adsorption studies

The values of the surface coverage for \textit{Biden pilosa} was obtained from the gasometric measurement. The Temkin, Freundlich, Langmuir and Frumkim isotherms and the correlation coefficient \((R^2)\) are applied to efficiently decide on the best fitted isotherm.

### 3. Results and discussion

Corrosion study of mild steel in 1.75 M HCl showed there was fast evolution of hydrogen gas in the blank solution (control) but as the inhibitors were further added to the acidic media at different concentrations there was reduction in the release of hydrogen as concentration increased. Figure 3.1 shows the plot of the volume of hydrogen gas evolved (ml) against time (mins) for \textit{Biden pilosa} extract at different concentrations on mild steel in 1.75 M HCl at room temperature and it reveals that the different concentrations of \textit{Biden pilosa} plant extracts inhibit corrosion mild steel in 1.75 M HCl when in comparison with the blank. The hydrogen gas evolved decreased with increased in concentration. 50% v/v concentration has the lowest amount of hydrogen gas evolved. This shows that the action of the inhibitors is concentration dependent. Figures 3.2 shows the plot of inhibition efficiency (%) against time (mins) for \textit{Biden pilosa} extract on Mild steel at different concentrations in 1.75 M HCl at room temperature. The plant extract inhibition efficiency increases as the concentration increases. 50% v/v concentration had the highest inhibition efficiency while 10% had the lowest inhibition efficiency. This is in agreement with Joseph et al., 2017 findings on \textit{Lecaniodiscus cupaniodes} plant extract on corrosion for mild steel in 0.5 M HCl [15].

The anti-corrosion properties of \textit{Biden pilosa} can be ascribed to the presence of alkaloids, tannins, saponins and phytic acid. Studies have reported the non-toxic inhibition properties of phytic and tannins on metals in aggressive media [16]. The ability of phytic acid to successfully bind to the cathodic sites of the metal surface has made it a good corrosion inhibitor [17].
Figure 3.1: The plot of volume of hydrogen gas evolved (ml) against time (mins) for *Biden pilosa* extract at different concentrations.

Figure 3.2: The graph of inhibition efficiency (%) against time (mins) for *Biden pilosa* extract on Mild steel at different concentrations. Figures 3.3 shows the Tafel plot of *Biden pilosa* extract using potentiodynamic polarization technique on Mild steel at different concentrations in 1.75 M HCl at room temperature and the result gotten were in form of curves. The plot shows that the blank was far away from the inhibitor. This indicates that the *Biden pilosa* is a good inhibitor. The current potential values moved more to the positive values as the extract concentration increases. Thus, as the potential difference increases the current also increases. The insignificant change in the tafel slope is an indication that corrosion inhibition of the extract is not attributed to the reactions that occur during metal dissolution neither is it due to the reaction of protons but rather, it is dependent on the adsorptive inhibition properties of the extract. The inhibitor is capable of reducing acidic dissolution by reducing the rate by which hydrogen is evolved by blocking the very active reaction sites on the surface of the mild steel. The extract can also protect the steel from further corrosive damage by shielding the unexposed part of the electrode [18].
Figure 3.3: The Tafel plot of *Biden pilosa* extract using potentiodynamic polarization technique on Mild steel at different.

Figure 3.3 and Table 3.1 show *Biden pilosa* leave extract does have any significant effect on the values of the corrosion potential since its $E_{corr}$ value did not exceed 0.85v. Thus, it acted as a mixed type of inhibitor because the anodic and cathodic region are of the same length [19]. The 40% concentration was the best because its potential difference value moved most to the positive region in Tafel plot. The corrosion rate of *Biden pilosa* leaves extract decreases as concentration increases as shown in figure 3.4. The 50% concentration has the lowest corrosion rate while 10% concentration has the highest corrosion rate.

**Table 3.1:** The result of *Biden pilosa* extract from the polarization technique at room temperature

| Concentration (%) | $E_{corr}$ (v) | $I_{corr}$ A | Bc (V/dec) | Ba (V/dec) |
|-------------------|----------------|--------------|------------|------------|
| Blank             | -0.50098       | 8.5080       | 0.0027013  | 0.0011530  |
| 10                | -0.46773       | 1.8202       | 0.0013699  | 0.0031099  |
| 20                | -0.46101       | 1.1454       | 0.0034061  | 0.0007427  |
| 30                | -0.46786       | 1.1465       | 0.0026751  | 0.0017198  |
| 40                | -0.46419       | 1.0564       | 0.0023866  | 0.0020314  |
| 50                | -0.46797       | 1.3890       | 0.0012216  | 0.0030502  |
Figure 3.4: The graph of corrosion rate (mm/yr) against concentration of *Biden pilosa* extract at different concentrations.

*Biden pilosa* extracts at room temperature was subjected to adsorption isotherms which are Langmuir, Freundlich, Temkim and Frumkim adsorption isotherm as shown in Figure 3.51, 3.52, 3.53 and 3.54 respectively. The plot shows it obeyed the Langmuir adsorption isotherm which describes the chemisorption of the adsorbed species and suggests a monolayer adsorption of the ascorbate unto the adsorbent which is expected to have a uniform slope. It can be seen in the result that *Biden pilosa* obeyed Langmuir isotherm because of its straight line graph which then means that the inhibitors monolayer attaches to the Mild steel surface without cross interaction between the species adsorbed.
**Figure 3.51:** A graph showing the Langmuir adsorption isotherm for *Biden pilosa* extract at different concentrations.

**Figure 3.52:** A graph showing the Freundlich adsorption isotherm for *Biden pilosa* extract at different concentrations.
Figure 3.53: A graph showing the Temkin adsorption isotherm for *Biden pilosa* extract at different concentrations.

Figure 3.54: A graph showing Frumkim adsorption isotherm of *Biden pilosa* extract at different concentrations at room temperature on mild steel.

**Conclusion**

In summary, *Biden pilosa* plant extract is a very good inhibitor on Mild steel corrosion in 1.75M HCl. The corrosion inhibition efficiency increased with an increase in concentration of the plant extracts which deduces the inhibitive properties of the plants extracts are concentration dependent. This study also showed that *Biden pilosa* leave extract obeyed Langmuir adsorption isotherm which is chemisorption which is an advantage for industries that still struggle with high level of corrosion.
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