Aqueous Extract of Zygophyllum album as Corrosion Inhibitor for Mild Steel in Sulphuric Acid Medium.

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ABSTRACT

The effect of aqueous extracts of Zygophyllum album on the corrosion of X52 mild steel in 1M sulphuric acid was investigated by Weight-loss determinations and electrochemical measurements. Potentiodynamic polarization curves indicated that the plant extracts behave as mixed-type inhibitors. The corrosion rates of steel and the inhibition efficiencies of the extract were calculated. The results show that the extract solution of the plant could serve as an effective inhibitor for the corrosion of steel in sulphuric acid medium. Inhibition was found to increase with increasing concentration of the plant extract up to a critical concentration.

Key words: plant extract; Zygophyllum-album.; inhibition; corrosion; X52 Steel.

Introduction:

One of the methods used to reduce the rate of metal corrosion is the addition of inhibitors. Many metals used in different human activities are susceptible to different mechanisms of corrosion due to their exposure to different corrosive media. Many studies have been carried out to find suitable compounds to be used as corrosion inhibitors in different aqueous solutions. These studies reported that there are many organic and inorganic compounds which act as inhibitors on the corrosion of steel. Many works were conducted to examine some naturally occurring substances as corrosion inhibitors for different metals in various environments (Eddy, 2008; Emeka, 2008; Oguzie, 2006; El-Etre, 2003; 2001; 2000; Qurashi et al., 1999; El-Etre, 1998; Kalman, 1990).

The aim of the present work is to find a natural cheap and environmentally safe substance that could be used for inhibiting the corrosion of X52. The use of such substances will establish simultaneously economic and environmental goals.

Experimental Methods

Mild steel coupons having percent composition of 0.9710Mn, 0.1261Si, 0.0021S, 0.0020P, 0.1039C and remaining Fe were used. Coupons with exposed surface area of 25 cm² (2 cm _ 5.6 cm _ 0.2 cm) were used for weight loss measurements. The steel coupons were left hanged in the test solution (1 M H₂SO₄) before recording the loss of their weights. The corrosion rate was calculated on the basis of the apparent surface area. The inhibition efficiencies calculations were based on the weight loss measurements at the end of the whole exposure period. The results of the weight loss experiments are the mean of three runs, each with a fresh sheet and fresh electrolyte. The percentage of inhibition efficiency was calculated using the following equation:

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Where \( W_1 \) and \( W_2 \) are weight losses of steel in uninhibited and inhibited solutions.

For potentiostatic experiments, a cylindrical rod of each sample was embedded in araldite leaving an exposed bottom area of 1.0 cm², and used as working electrode. Each working electrode was polished with different grades of emery papers, degreased with acetone and rinsed with distilled water, before its immersion in the test solution. Potentiostatic polarization studies were carried out using EG&G model 363 Potentiostat/Galvanostat. Three-compartment cell with a saturated calomel reference electrode (SCE) and a platinum foil auxiliary electrode was used. For potentiodynamic experiments, the working electrode was held at the potential of hydrogen evolution for 10 min before the starting of the potential sweep, to get rid of any pre-immersion oxide film which may be present on the surface. The electrode was then disconnected from the potentiostat, gently shaken in the solution to release the hydrogen bubbles attached to its surface and left in the test solution until the reach of its steady state potential. Once the electrode acquires its steady state potential it is reconnected to the potentiostat for the polarization experiment procedure. The inhibition efficiency \( \text{IE} \) was calculated using the following equation:

\[
\text{IE}\% = \left( \frac{I - I_i}{I} \right) \times 100
\]

Where \( I \) and \( I_i \) are the corrosion rates in free and inhibited solutions, respectively.

**Solutions Preparation**

Double distilled water and analytical reagent-grade \( \text{H}_2\text{SO}_4 \) were used for preparing solutions. Stock solution of plant extracts was obtained by drying the plant for 15 day and grinding to powdery form. A 10 g of the powder was refluxed in 100 mL double distilled water for 2 hours in an oven at 80°C. The refluxed solution was filtered to remove any contamination. The concentration of the stock solution was determined by evaporating 10 mL of the filtrate and weighing the residue. Before each experiment, 1M \( \text{H}_2\text{SO}_4 \) is added to an appropriate volume of the stock solution and double distilled water to obtain a solution of 1M \( \text{H}_2\text{SO}_4 \) and the required concentration of the extract. All chemicals used for preparing the test solutions were of analytical grade and the experiments were carried out at room temperature, 27 ± 1°C.

**Results and discussions**

**Weight Loss Measurements**

<table>
<thead>
<tr>
<th>C (ppm)</th>
<th>50</th>
<th>200</th>
<th>400</th>
<th>600</th>
<th>800</th>
<th>1000</th>
<th>1200</th>
<th>1400</th>
<th>1600</th>
<th>1800</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (mm/an)</td>
<td>22.53</td>
<td>15.09</td>
<td>13.47</td>
<td>11.45</td>
<td>7.99</td>
<td>4.93</td>
<td>6.82</td>
<td>0.83</td>
<td>0.95</td>
<td>1.21</td>
<td>1.82</td>
</tr>
<tr>
<td>IE (%)</td>
<td>6.14</td>
<td>37.13</td>
<td>44.04</td>
<td>52.28</td>
<td>66.73</td>
<td>79.95</td>
<td>88.66</td>
<td>96.69</td>
<td>96.04</td>
<td>94.60</td>
<td>92.45</td>
</tr>
</tbody>
</table>

Fig. 1 presents the dependence of corrosion rate and inhibition efficiency \( \text{IE}\% \) of mild steel exposed to 1M sulphuric acid on the concentration (ppm) of the plant extract studied at 27 °C (calculated from gravimetric data).

The increase of plant extract concentration increased the corrosion inhibition efficiency. The maximum inhibition rate is estimated to 96.69% in 10% sulphuric acid at 1400 ppm.

![Fig. 1: Efficiency plots of mild steel immersed in 1M sulphuric acid with plant extract at 27 °C](image-url)
According to the results, we observe that the addition of the plant extract causes a decrease in the rate of corrosion for the concentrations 200, 600, 1000 and 1400 ppm, and an increase in the rate of corrosion for concentration greater than 1400 ppm. The optimal concentration of inhibitor is 1400 ppm for a rate of inhibition equal to 98.07%. The corrosion rate increase when the concentration of inhibitor exceeds 1400 ppm may be attributed to the decrease in the effectiveness of the inhibitor when excessively added.

**Conclusion**

The plant extracts of *Zygophyllum-album. L* can be used as an excellent corrosion inhibitor for steel in acidic medium at room temperature. To obtain the maximum protection efficiency, critical plant extract concentration should be determined. The inhibition mechanism depends on the formation of a stable plant extract-complex on the steel surface.

Polarization studies reveal that the extracts behave as mixed type inhibitors.

**References**


