CORROSION INHIBITION OF ALUMINIUM IN ACIDIC MEDIA BY THEACEAE EXTRACT

Issaad Fatima Zohra, Louafi Fadila et Sellami Seif Eddine
U. R. CHEMS, Département of Chemistry Mentouri University, Constantine, Algeria

Abstract:
Corrosion is the destructive attack on a metal or metal alloy by chemical or electrochemical reaction with its environment, the use of inhibitors can protect the metal by forming a film on the surface.

Large numbers of compounds were studied but most of these are toxic and expensive, fortunately the plant extract could be present the ideal solution through the presence of some phytochemical constituents which is adsorbed on the surface of the metal and protect it.

The effect of ethanolic extract of *Camellia Sinensis* as an inhibitor on the corrosion of aluminium alloy in 1 M HCl was investigated by the gravimetric technic.

The inhibiting efficiencies of the extract were found to increases with increasing concentration of inhibitor but decreases with increasing in temperature.

The results obtained shows that the adsorption of plant extracts on the surface obey Langmuir adsorption isotherm. The physical adsorption is proposed according to the thermodynamic parameters.

Key words: corrosion inhibition, aluminium, adsorption isotherm, *Camellia Sinensis*.

1 Introduction

Aluminum and its alloys are widely used in the industry due to its low cost, light weight and electrical conductivity. However the Acid solutions are often used in industry dissolve the metal [1].

Protection of metallic surfaces can be achieved by addition of some compounds, known as corrosion inhibitors.

The scientific corrosion literature has descriptions several chemical compounds protect the corrosion of metals, the presence of heteroatoms (such as sulphur, phosphorus, nitrogen and oxygen)2 and aromatic rings in the organic inhibitors facilitates the adsorption of the inhibitor on the metal surface. e.g. fluconazole, pyridine etc3. On the other hand, the inorganic inhibitors which are mainly oxidizing agents such as chromates and molibdates act as anodic inhibitors and their metallic atoms are enclosed in the film improving its corrosion resistance.
Considerations of cost, toxicity and environmental factors there exists the need to develop a new class of corrosion inhibitors with low toxicity and good efficiency.

Those natural products of plant origin contain different organic compounds (e.g. alkaloids, tannins) shown the inhibitive effect is due to the adsorption of molecules in the plant on the surface of the metal, very interesting studies are published as Ficus religeosa, Schinopsis lorentzii and lawsonia.

The objective of the present work is to study the inhibitive action of Camellia Sinensis extract on Al in 1M HCl using weight loss and thermometric techniques of 25–40 °C.

2 EXPERIMENTAL PARTS

2.1 Material preparation:
For gravimetric measurement the composite of aluminum is as follow: 96.05% pure aluminum, O 2.05%, Si 0.38%, Ca 0.21%, Fe 0.40%, and Ag 0.92%. (The analysis is made in the center of scanning electron microscopy and microanalysis at the University of Réene, France).

The sheet was cut to form square of 1cm2, pre-treated of the surface was carried out polishing using abrasive papers, rinsing with ethanol, distilled water and were degreased subsequently with acetone and dried at room temperature.

2.2 Extract preparation:
Camellia Sinensis was already dried and ground to powder form and soaked in a solution of 96% ethanol for 4 days, the solution was filtered and concentrated initially using vacuum evaporator and finally by evaporation to dryness on a steam bath to obtain a solid extract devoid of ethanol.

The extract solution was then diluted using the solution of the test medium for 1M HCl concentrations between 8 and 14 %V/V.

2.3 gravimetric measurements:
The weight loss measurements are a first approach to the study of the inhibition of corrosion of a metal.
The species are immersed in a 1M HCl solution without and with inhibitor. The percentage inhibition efficiency (E (%)) was calculated using the relationship:

\[
E\% = \left( \frac{W_{\text{corr.}} - W_{\text{corr.(inhibit)}}}{W_{\text{corr.}}} \right) \times 100
\]
Where $W_{corr}$ and $W_{corr (inh)}$ are the corrosion rates of Al in the absence and presence of *Camellia Sinensis* respectively.

## 2 RESULTS AND DISCUSSION

### 2.1 The effect of immersion temperature on the efficiency of inhibitors

Fig. 1 shows the change of time immersions for 5 hours at room temperature on the effectiveness of the inhibitor at various concentrations. The efficiency reaches maximum value 91.91% to 14% of inhibitor concentration.

After one hour there is decrease in inhibition efficiently, may be for desorption of inhibitors molecules.

![Figure 1: Effect of immersion time on efficiency Inhibitors](image)

### 2.2 The effect of immersion time on the efficiency of inhibitor:

According to Fig. 2, we observe that the efficiency increases with the increase of inhibitor concentration and the decrease of temperature.
According to several articles [6-7], we conclude that the type of adsorption of molecules on metal surface is physisorption.

![Figure 2: Effect of immersion time on the efficiency of inhibitors](image)

2.3 **Kinetic parameters:**

We notice from Fig. 3 in the absence or presence of inhibitors curves \( \ln W_{\text{inh}} = f \left( \frac{1}{T} \right) \) follows the Arrhenius law:

\[
\log W = \left( \frac{-E_a}{2.303RT} \right) + \log A \tag{2}
\]

- \( E_a \): Activation energy
- R: Perfect gas constant
- T: Absolute temperature
Can be calculated activation energies from the Arrhenius relation, the values of the activation energy $E_a$ with and without addition of inhibitors are given in Table 1.

Table 1 - Activation energy of dissolution of aluminum in HCl 1m only and in the presence of inhibitors.

<table>
<thead>
<tr>
<th>Concentration (% v/v)</th>
<th>$E_a$ (kJ/mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>33.88</td>
</tr>
<tr>
<td>8</td>
<td>116.69</td>
</tr>
<tr>
<td>10</td>
<td>112.63</td>
</tr>
<tr>
<td>12</td>
<td>98.41</td>
</tr>
<tr>
<td>116.37</td>
<td>116.37</td>
</tr>
</tbody>
</table>

According to the results, the energy of activation in absence of inhibitor is Lower than that corresponding to blank solution. The increase in energy in the presence of the inhibitor is linked to the reduction of absorbed molecules with the increase in temperature is related to the covered part of the metal surface.

This explanation suggests a mode of physical adsorption.
2.4 Adsorption isotherm:

Isotherms are very important for determine the mechanism of the electrochemical reaction. The isotherms of Langmuir, Temkin and Framkin are tested to find the suitable isotherm. It was found that Langmuir isotherm is appropriate Fig. 4

![Figure 4: Langmuir adsorption isotherm of aluminum in 1M HCl in the presence of inhibitor at 25 °C.](image)

Thermodynamic parameters presented in Table II are calculated using the following equation:

\[
\frac{C}{\theta} = nK_{ads} + nC
\]  

(3)

**Tableau 2 – Thermodynamics parameters**

<table>
<thead>
<tr>
<th>Temperature (°K)</th>
<th>K ads. (M)</th>
<th>ΔG° ads.(kJ/mole)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>298</td>
<td>84.7457</td>
<td>-20.940</td>
<td>0.99781</td>
</tr>
<tr>
<td>303</td>
<td>12.4501</td>
<td>-16.462</td>
<td>0.93553</td>
</tr>
<tr>
<td>313</td>
<td>1.5523</td>
<td>-11.590</td>
<td>0.95887</td>
</tr>
</tbody>
</table>
By plotting values of C/ϴ versus C, straight line graphs were obtained Fig. 4 which proves that Langmuir adsorption isotherm is obeyed for each temperature over the range of concentrations studied.

\[ K_{ads} \] is related to the standard free energy of adsorption by the following equation:

\[ \Delta G^\circ_{ads} = -2.303RT \log(55.5K_{ads}) \]  

(4)

The value is the concentration of water in solution. The negative value of \( \Delta G^\circ_{ads} \), indicate the spontaneity of the adsorption process and the stability of the adsorbed layer on the metal surface. Generally, the values of \( \Delta G^\circ_{ads} \), close to -20 kJ mol\(^{-1}\) or less negative, are related to electrostatic interactions between charged molecules and charged metal (physical adsorption), While those close to -40 kJ mol\(^{-1}\) or more imply a negative charge transfer between organic molecules and the metal surface (chemisorption).

The value of \( \Delta G^\circ_{ads} \), shows that the adsorption of the extract is physical.

5. Conclusion:

1. The extract of green tea is Camellia Sinensis as a good corrosion inhibitor for aluminum in 1M HCl

2. The adsorption process is spontaneous and follows the Langmuir adsorption isotherm.

3. The values of the free energy of adsorption calculated indicate strong, spontaneous and physical adsorption of the extracts on the Al surface.

4. The presence of the extract increases the activation energy of the corrosion reaction

Acknowledgement

The author is grateful to Mr Ali Yousri El-Etre “Department of Chemistry, Faculty of Science, Benha University, Benha, Egypt” for contributing to the production of this article.

Références


