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Plant Extracts as Environmentally-Friendly Corrosion Inhibitors: a Review

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Abstract: *The corrosion inhibition of mild steel in acid media by the Plant extract has been studied using weight loss methods, potentiodynamic polarization and electrochemical impedance spectroscopy techniques. The results show that the inhibition efficiency increases with the increase of the extract concentration. 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.*

Keywords: *Plant extract, mild steel, weight loss.*

1. INTRODUCTION

Corrosion is generally regarded as the deterioration of metals due to chemical attack or reaction with a belligerent environment. It is a constant and persistent problem, often difficult to eliminate completely. The corrosion of mild steel and other metals is accentuated in the presence of an aggressive media such as acid. Therefore industrial process such as acid cleaning, acid descaling, acid pickling, and other oil well acidizing, require the use of corrosion inhibitors[1, 2].

Many types of inhibitors have been thoroughly synthesized and used to combat corrosion problem. Most effective inhibitors are organic compounds containing N, S and/or O atoms. These compounds can be adsorbed on the metal surface, block the active sites and thereby reduce the corrosion rate. Most of the investigated compounds are generally toxic and cause many severe environmental hazards. Hence the use of natural products as eco-friendly and harmless corrosion inhibitors is gaining an increasing popularity[2,3].

Natural products are nontoxic, biodegradable and readily available. They have been used widely as inhibitors. Many research groups have reported the successful use of naturally plant-derived substances to restrain the metal corrosion[1-10].

Plant extracts are viewed as an incredibly rich source of naturally synthesized chemical compounds that can be extracted by simple procedures with low cost and are biodegradable in the environment. Plant leaves extracts as effective corrosion inhibitors of iron or steel in acidic media have been reported, such as Cotula cinerae, Retama retam and Artemisia herba alba[13], Zygophyllum album[14], Atractylis serratuloides[15], tamarix gallica[16].

Through these studies, it is agreed that the inhibition performance of plant extract is normally ascribed to the presence in their composition of complex organic species such as tannins, alkaloids and nitrogen bases, carbohydrates, amino acids and proteins as well as hydrolysis products. These organic compounds contain polar functions with N, S, O atoms as well as conjugated double bonds or aromatic rings in their molecular structures, which are the major adsorption centers.

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The aim of the present study is to investigate the corrosion inhibition effect of Plant extract as a cheap and environment friendly corrosion inhibitor for mild steel in acid media by weight loss and Polarization Measurement.

2. Experimental

2.1 Preparation of Plant Extract

Plant leaves were soaked in deionized water (500ml) and refluxed for 5 h. The aqueous solution was filtered and concentrated to 100 ml. After filtration, different concentrations were prepared.

2.2 Weight Loss Method

Different mild steel samples were immersed in hanging positions in 1N HCl solution containing different concentrations of inhibitors for three hours. Samples were weighed before and after immersion and weight differences were determined. The degree of surface coverage (θ) and percentage inhibition efficiency (IE %) were calculated from the following equations

Surface Coverage (θ) = $W_0 - W / W_0$
Inhibition Efficiency (IE %) = $(W_0 - W / W_0)$ X 100

where W_0 and W are the weight losses of mild steel without and with the inhibitor respectively. It was assumed that the surface was saturated with adsorbed inhibitor molecules, that is θ = 1.

2.3 Electrochemical Measurements

Electrochemical experiments were carried out in a conventional three-electrode cell with a platnum counter electrode (CE) and a saturated calomel electrode (SCE) coupled to a fine Luggin capillary as the reference electrode.
Impedance measurements were carried out in the frequency range from 0.1 to 10000 Hz using an amplitude of 20 mV and 10 mV peak to peak with an AC signal at the open-circuit potential. The impedance diagrams were plotted in the nyquist representation. Charge transfer resistance (Rct) values were obtained by subtracting the high-frequency impedance. The percentage inhibition efficiency was calculated from the equation:

Inhibition Efficiency (IE%) = (Rct - R'ct / Rct) x 100

where R'ct and Rct are the corrosion current of mild steel with and without inhibitor respectively.

3. Results and Discussion

3.1. Weight Loss Studies

The values of inhibition efficiency (IE%) and the corrosion rate (CR) obtained from weight loss method at different concentrations of plant extractions**.** It follows from the data that the weight decreased and therefore corrosion inhibition increased with increase in inhibitor concentration. It was also observed that corrosion rate decreased with increase in inhibitor concentration. The increased inhibition efficiency and decreased corrosion rate might be due to the increased adsorption and increased surface coverage (θ) of inhibitor on mild steel surface with increase in concentration.

3.2 Electrochemical Measurements

The electrochemical parameters prove that corrosion current (Icorr) decreases clearly in the presence of plant extract and the inhibition rate increases with increasing extract concentration. These findings provide evidence for the inhibitive effect of the plant extract in HCl medium. The values of both anodic and cathodic Tafel constants ba and bc respectively have clearly changed in the presence of the extract.

The extract influences both the anodic and cathodic overpotentials and shifts Tafel lines in both directions. This result confirms the mixed inhibition mode of the extract. It can also be noted that, the increasing linear polarization (Rp) values corroborate the corrosion inhibitive nature of the extract.

In this context the inhibitive effect of extracts of Cotula cinerae, Retama retam and Artemisia herba alba plants on the corrosion of X52 mild steel in aqueous 20 % (2.3 M) sulfuric acid was investigated. Weight-loss determinations and electrochemical measurements

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were performed. Polarization curves indicated that the plant extracts behave as mixed-type inhibitors. The inhibition efficiencies of the extracts were ranging between 84% and 88%[11].

Moreover, the aqueous extract of Zygophyllum album. L revealed that it can be used as corrosion inhibitor of steel in acidic medium at room temperature and at a concentration of 1400 ppm to reach an inhibition rate around 98%[12].

In another study, we investigated the inhibitive properties of the methanolic extracts of three parts of the plant Atractylis serratuloides towards the corrosion of X52 steel in acidic medium and found that the plant extracts may cause more than 80% of inhibition rate at a concentration around 1200 ppm[13].

Furthermore the inhibitive action of aqueous extract of tamarix gallica on the corrosion of mild steel in 1m sulphuric acid was assessed by weight-loss method and polarization techniques and the results show that the inhibition effect is more than 98% at 1400 ppm[14].

Comparing these results to what was found in the present study we can conclude plant extract has a good inhibitive potential and can be used to replace toxic chemicals.

The increasing charge transfer resistance Rct values imply reduced corrosion rate in the presence of the plant extract. This it is confirmed that the plant extract show good corrosion inhibition efficiency.

4. Conclusion

Acid extract of plant acts as a good corrosion inhibitor for mild steel in Acid media. Inhibition efficiency increases with inhibitor concentration. Corrosion inhibition is mainly being due to the adsorption of the plant constituents on the mild steel surface. Polarization studies indicated that the extract is mixed type inhibiting both cathodic as well as anodic reactions.

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