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Dryopteris Plant Extracts as a Green Inhibitor for the Corrosion Inhibition of Mild Steel in Acidic Media

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Abstract

The corrosion inhibitive properties of Dryopteris wallichiana leaves extract was investigated for mild steel in different concentration of acidic medium of HCl. This study revealed that the corrosion rate increases with the increase in acid concentration whereas the corrosion rate decreases with the increase in inhibitor concentration. It is associated with the action of corrosive medium with the metal sample(MS) and the active phytochemicals constituent present in the inhibitor. The maximum inhibition efficiency was found to be 85.84% and the maximum corrosion rate was found to be 214.8gm $m^{-2}hr^{-1}$ in 2M HCl.

Keywords: Green inhibitor, Weight loss, Plant extract, Corrosion rate, Inhibition efficiency.

Introduction

Corrosion is the destruction of metal by chemical or electrochemical reactionsin its atmosphere. It is a natural process. It is a continuous and regular problem that is never eliminated.[1] Prevention would be preferable to complete elimination. It affects our daily lives in direct or indirect ways. It degrades the useful properties of metals. It is the most serious problems in economic factors. [2]. When corrosion inhibitors are present, metal corrosion rate can be highly reduced.

Corrosion inhibitors can be separates in mainly two groups i.e., inorganic and organic. Most of the inorganic inhibitors are not environmentally safe. Therefore, the extract of green plants leaves has been suggested. In green plants, they contain many compounds to control corrosion problems without damaging the ecosystem of the environment [3]. In many research, corrosion inhibition by the use of synthetic chemical is widely used because of faster effective. Synthesized inhibitors cost a lot of money and in the same time could negatively affect the environment. So, many researchers are focused on

green inhibitors because it is non-toxic, renewable, less cost and eco-friendly materials.[4] Corrosion is becoming an issue in a variety of industries, including oli and chemical production. It is economically wasteful, costing industrialized countries 4.5% of their annual GDP. A basic understanding of electrochemistry material science, and corrosion might potentially save the nation 25% of this loss. Dryopteris plants are commonly called as the wood ferns. These ferns are easily found and easy to grow. The major constituents of Dryopteris fern include flavonoids and terpenoids. So, they are considered as effective, eco-friendly and natural green inhibitor for mild steel in hydrochloric acid solution. Hence, the main aim of this study is to produce corrosion inhibitor from Dryopteris plant extract and determine the inhibition rate for mild steel in acid solution [5].

Dryopteris wallichiana, commonly called the wood ferns or male ferns, is a fern genus in the family Dryopteridaceae.Its height ranges from 3 to 5 feet.It is found growing in cool mountainous forest in Japan, Hawaii, Mexico, China, Africa and the foothills of Himalaya.It is one of the most attractive garden ferns, with thin, dark, glossy midnight green leaf that forms a giant clump. Nathaniel Wallich(1786-1854), Danish botanist, was indeed the inspiration for the name. The major constituents of Dryopteris ferns include flavonoids and terpenoids so they are considered as effective eco-friendly and natural green inhibitor for mild steel in hydrochloric acid solution. Hence, the main aim of this study is to produce corrosion inhibitors from Dryopteris plant extract and determine the inhibition rate for mild steel in acid solution [6].

Figure1*DryopterisWallichiana*

Materials and Methods

Material Preparation

The experiment was carried out using steel coupons purchased from the local market; each area was about 1x2cm. After polishing and cleaning the coupons with emery paper they were washed with doubled distilled water and acetone. They dried at room temperature and left in a desiccators over a Silica gel for 1 hour. Each sample was weighed accurately to the four decimal digital balance before and after the experiment.

Extract Preparation

Healthy *Dryopteris Wallachiana* leaves were collected from local area of Damak-Jhapa. The *Dryopteris Wallachiana* leaves were washed and dried at room temperature for two weeks and powdered for extraction. *Dryopteris Wallachiana* extract was prepared by adding 100gm of powdered leaves in 1000ml of de-ionized water. It was then heated in a Soxhlet apparatus and the solution was reduced to 250ml. It was then filtered and used for corrosion study.

Weight Loss Study

The cleaned and pre-weighed MS specimens were immersed in 1M and 2M HCl solution for 5 hours regular interval of 1 hour. After each exposure the specimens were washed with de-ionized water, dried and weighed. Then the MS specimens were placed separately in 10ml, 20ml, and 30ml inhibitor extract along with 100ml of acid. From the initial and final mass of the specimen, the weight loss was calculated with and without inhibitor extract.

The rate of corrosion is estimated by equation:

$$\text{Corrosion rate(R)}=\frac{\text{Weight loss (gm)}}{\text{Area (m}^2)\times\text{Time(hrs)}} \quad \text{.....(i)}$$

Where, ΔW= Weight loss of the sample in gram

A= Area of the sample in cm

t= time in hours

Similarly,

The following equation was used to calculate the inhibitory efficiency (IE%) and surface coverage (θ):

$$\text{IE (\%)} = \frac{W_o - W_i}{W_o} \times 100 \quad \text{.....(ii)}$$

Where, W_o= Weight loss without inhibitor.

W_i= Weight loss with inhibitor.

$$\text{And, surface coverage } (\theta) = \frac{\text{IE\%}}{100} \quad \text{.....(iii)}$$

Results and Discussion

Effect of concentration on weight loss

The weight loss of the mild steel was calculated by using the equation:

$$\Delta W = W_1 - W_2$$

Where, W_1 and W_2 are the weight loss of mild steel sample with and without inhibitor. Table 1 shows the results of a weight loss, corrosion rate, inhibition efficiency, and surface coverage experiment for mild steel immersed in 1M and 2M HCl with and without inhibitor for 5 hours. 2M HCl without inhibitor extract resulted in the greatest

weight loss. The inclusion of Dryopteris leaves extract decreased weight loss and delayed the corrosive activity as shown in Figure 2.

Table 1Corrosion parameters for mild steel in 1M and 2M HCl in absence and presence of optimum concentration of the inhibitor studied at 5 hours.

Concentration	Weight Loss (ΔW)	Corrosion Rate (R)	Inhibition Efficiency (IE)	Surface Coverage (θ)
1MHCl (Blank)	0.1204	120.4	0	0
10ml Extract	0.0735	73.5	37.7	0.377
20ml	0.0558	55.8	53.65	0.5365
30ml	0.1589	31.19	73.5	0.735
2M HCl (Blank)	0.2148	214.8	0	0
10ml Extract	0.0816	81.6	62.01	0.6201
20ml	0.078	78.6	63.4	0.634
30ml	0.0435	43.5	79.75	0.7975

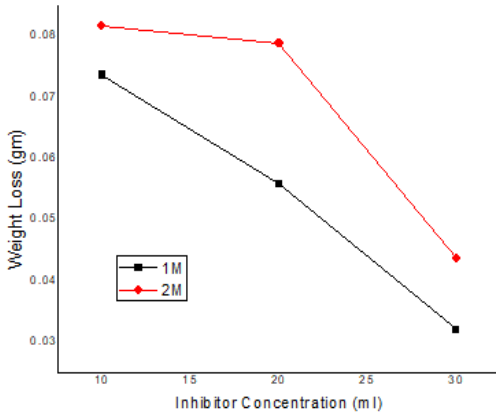

Figure 2Variation of weight loss with the Dryopteris plant extract.

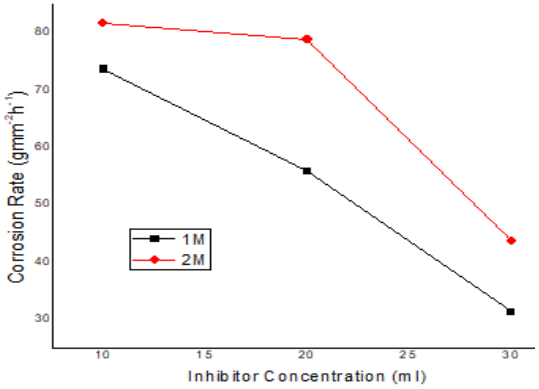

Figure 3Variation of corrosion rate with Concentration of the Concentration of Dryopteris plant Extract.

Effect of concentration on corrosion rate

From the weight loss method, the corrosion rate for the mild steel sample in 1M and 2M were calculated. In Table 1, the corrosion rate of mild steel increases with increased in acid concentration due to the action of corrosive medium i.e., HCl with the component of the mild steel sample. The result in Table 1 shows that the addition of Dryopteris leaves extract i.e., 10ml, 20ml, 30ml to the electrolyte decreases the corrosion rate of mild steel sample. Figure 3 shows the effect of acid and inhibitor concentration on corrosion rate. It illustrates that the corrosion rate decreases with the increase in inhibitor concentration.

Effect of concentration with inhibition efficiency

Table 1 shows the relationship between inhibitor concentration and inhibition efficiency. As shown in Figure 5, the effectiveness of extract inhibition increases as the concentration of inhibitor extract increases because the fraction of surface covered by the adsorbed molecule increases as the concentration of the extract increases.The inhibitory efficiency improves progressively as the concentration of extract increases up to 30. It was discovered that the greatest inhibitory efficiency was 85.84%.

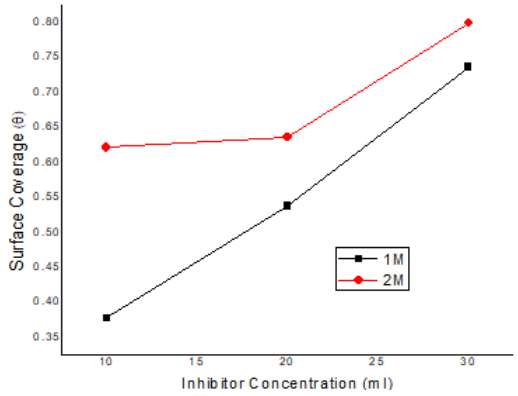

Figure4Variation of surface coverage with the concentration of Dryopteris plant extract

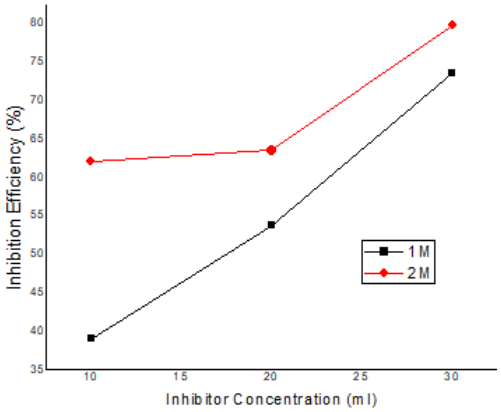

Figure 5Variation of inhibition efficiency with the concentration of Dryopteris plant extract.

Effect of concentration on surface coverage

Surface coverage (θ) is directly proportional to the concentration of the inhibitor since it is related to the number of adsorbed molecules on the surface of MS sample. Hence, as the concentration of the inhibitor increases the molecules adsorbing on the surface also increases and hence the inhibitory effect of extract also increases that mitigate the corrosion. It was illustrated in Figure 4.

Conclusion

From the above experiment it is quite obvious that *Dryopteris wallichiana* plants can be the efficient green inhibitor which could replace the toxic and environmentally unfriendly synthetic inhibitor and be its replacement in a wide area of metal application. In different concentrations of acid, such as 1M and 2M HCl, several corrosion metrics such as weight loss, corrosion rate, inhibition efficiency, and surface coverage were investigated. The inhibitory efficiency improves progressively as the concentration of extract increases up to 30. It was discovered that the greatest inhibitory efficiency was 85.84%.It was observed that the acid with the highest concentration induces the most weight loss, which is around 214.8g/m^2hr.The weight loss and corrosion rate values were decreased whereas surface coverage and inhibition efficiency were increased.

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