Anticorrosive Activity of *Rosemarinus officinalis* L. Leaves Extract Against Mild Steel in Dilute Hydrochloric Acid

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ABSTRACT: ***The rosemary (Rosemarinus officialis L) leaves extract was evaluated for inhibitive action towards the corrosion of mild steel in 0.1 N HCl at ambient temperature by gravimetric and potential monitoring techniques. There was a drastic reduction in weight loss of test samples. The corrosion inhibition efficiency of extract varied with concentration of extract and duration of immersion of mild steel in corrosive medium. The 100% leaves extract of Rosemarinus officinalis L gave 98.33% corrosion inhibition efficiency as compared to control. The corrosion rate was significantly reduced and curtailed to 0.27 mm/year at 100% leaves extract concentration. The corrosion inhibition of leaves extract of Rosemarinus officialis L is attributed to protective film formed by the complex organic compounds of the extract.***
Keywords - Hydrochloric acid, weight loss, Corrosion inhibition, Mild steel, Rosemarinus officinalis L.

I. INTRODUCTION

Mild steel is a material of choice due to its characteristics and find wide application in most of the chemical industries. It suffers from severe corrosion and cause considerable losses of metal when comes in contact with acidic media for removing scales and rusts in metal finishing industry, cleaning of boilers heat exchangers [1]. In order to control the corrosion of metals various techniques are applied [2]. However, use of inhibitors is one of the practical methods for protection against corrosion especially in acid media to prevent unexpected dissolution and acid consumption [3,4]. Though many synthetic compounds have shown good anticorrosive activity, most of them are highly toxic to both human beings and environment. The safety and environmental issues of corrosion inhibitors arisen in industries has always been a global concern [5]. The known toxic and hazardous effect of most synthetic corrosion inhibitors have driven the interest of the scientists to look for naturally occurring products as corrosion inhibitors as they are inexpensive, readily available, biodegradable, eco-friendly and environmentally acceptable renewable sources of materials [6,7,8]. The literature revealed that extracts of *Azadirachta indica* [9], *Occimum viridis* [10], *Strychnos nux-vomica* [7], *Prosopis cineraria* [11], *Hibiscus sabdariffa* [9], olive [12], *Datura stramonium* [7], *Aloe vera* [13] and *Phyllantus amarus* [14] are good inhibitors for metals.

In order to contribute the growing interest of scientists in search of environmentally benign corrosion inhibitor, the possible utilization of *Rosemarinus officinalis* extract as corrosion inhibitor is explored in present work.

II. MATERIALS AND METHODS

Preparation of specimen

The mild steel sample was procured from local market of Quetta, Balochistan, Pakistan. The nominal percent composition of the mild steel sample was C 0.22, Si 0.29, Mn 0.51, S 0.04, Al 0.11, Cu 0.04, Cr 0.03, P 0.05 and Ni 0.06, the rest iron. The sample was cut in to average dimensions of 20 X 40 X 1.5 mm. The samples were descaled with wire brush and then ground with silicon carbide abrasive paper of 320, 400 and 600 grits, polished and thoroughly rinsed in ultrasonic cleaner, dried and stored in desiccator for weight loss experiments.

The specimens for potential measurements were prepared by mounting insulated flexible wire by spot welding were in turn mounted in araldite resin.

Preparation of leaf extract

The rosemary leaves were collected from the rosemary plants grown in PCSIR laboratories, Quetta Campus, oven dried at 70^{o}C. The leaves were finely powdered in a blender and saved in air tight glass container.

25 g of dried and powdered leaves of the plant were refluxed with 0.1 M HCl for about 5 h and the mixture was kept overnight. The solution was filtered off and the filtrate was diluted to 250 ml with 0.1 M HCl and marked as 100 % (as obtained).

Preparation of test media

The test media were prepared by diluting calculated volume of extract in 0.1 N HCl. Four concentrations of extract i.e., 25, 50, 75 and 100 % were made. 0.1 N HCl without extract treated as Control.

Weight loss experiment

Weighed test pieces were fully immersed, separately for 21 days in each of the prepared concentration and control in triplicate. Each of the test specimens was taken out after passage of every three days, washed with distilled water, rinsed with methanol, dried, re-weighed and Weight loss was calculated. From the weight loss results, the inhibition efficiency (I.E %) of the inhibitor was calculated by using following Equation:

$$I.E.\% = \frac{W1 - W2}{W1} \times 100$$

Whereas W1 and W2 are the corrosion rate (mm/year) for mild steel in the absence and presence of the inhibitor in HCl solution, respectively.

All the experiments were performed at the ambient temperature.

The corrosion rate millimeter per year (mm/year) was calculated as under:

$$\text{Corrosion rate (mm/year)} = 87.6*(W/DAT)$$

Where, W is the loss in weight expressed in mg, D is mild steel sample density (gm/cm^3), A is the area of metal surface exposed (cm^2), T is the exposure time (hours), and 87.6 is the conversion factor.

Potential measurements

The mounted and polished specimens were tested for potential measurements. They were immersed in turns in each of the different test media containing different concentrations of the extract. The same tests were also performed in the acid without the extract addition. The potential was recorded at three days intervals using a digital multi-meter and saturated calomel electrode (S.C.E.) as the reference electrode. Curves of variation of potential (mV) vs. S.C.E with exposure time were obtained.

III. RESULTS AND DISCUSSION

The results of weight loss experiment for mild specimen imersed in 0.1 N HCl with and without Rosemarry extract were presented in Fig. 1. Highest magnitude of weight loss was recorded in 0.1 N HCl without Rosemarry extract throughout the experiment period. The addition of rosemarry extract to the test medium significantly reduced the weight loss. The addition of rosemarry extract not only reduced the loss in weight but also delayed the action of test medium. It was also obseved that loss in weight of mild steel was dependent on the concentration of rosemarry extract in the test medium. Maximum delay in action of test medium was observed upto 6th day in 100% rosemarry extract. The reduction in weight loss was 97.41 % as compared to control after 21 days. These results confirm the good corrosion inhibitory effect of rosemarry extract towards the corrosion of mild steel in HCl at the concentratrions used in the study. Loto and Popoola [15] have also reported maximum corrosion inhibition in presence of 100% extract of kola nuts. The increase in weight loss of mild steel was also observed with the passage of time as by Loto *et al.* [16] in presence of Neem leaf extract.

The corrosion rate vs exposure time calculated from the weight loss studies presented in Fig. 2 showed that the corrosion rate of mild steel in control medium increased to some extent with the passage of time i.e., up to 9 days, remained more or less constant till 15 days of exposure than decrease there after. The decrease in corrosion rate due to contamination of corrosion medium with the corrosion product [15]. The addition of rosemarry extract retarded the corrosion rate to great extent and reduced to 0.405 mm/year in in added rosemarry extract concentration of 100% at the end of experiment. The reduction in corrosion rate was proportional to concentration of extract in the corrosion medium.

The corosion inhibition efficiency vs exposure time of rosemarry extract (Fig. 3) revealed that the corrosion inhibition efficiency was increased with increase in concentration of the extract and remained 68.24 to 100% in various concentrations. The increase in corrosion inhibition efficiency was also observed by Pruthvirag *et al.* [8] in presence of *Clerodendrum phlomidis* leaves extract.

A decrease in corrosion efficiency with the passage of time was also observed. Maximum decrease in corrosion inhibition efficiency recorded was 25.09% at 25% and minimum i.e. 2.59% in case of 100% extract concentration after 21 days exposure to corosion media. This behaviour explained by Kumar *et al.* [17] as the interaction of inhibitor molecules with the metal surface resulting in adsorption. The extent of increase in adsorption with the increase in inhibitor concentration lead to the increased inhibition efficiency. The effectiveness of rosemarry extract towards corrosion could be attributed to the presence of organic componds which act as inhibiting film former on the surface of mild steel. Dorman *et al.* [18] and Kosar *et al.* [19] have reported tanins and other organic compounds in water extract of rosemarry leaves. Tanins are the effective corrosion inhibitors [20,21]. Tanins along with saponins and alkaloids are known to be active constituents of green corosion inhibitors [22] because they have high complexation effinity to metals. Odiongenyi *et al.* [24] have reported that the inhibitor act by being adsorbed on surface of mild steel which is spontaneous and occurs by physical adsorption. The effectiveness of rosemarry extract towards corrosion could be associated with presence of organic componds which act as inhibiting film former on the surface of mild steel. Pruthvirag *et al.* [8] have confirmed the formation of film on the surface of mild steel by contituents of *Clerodendrum phlomidis* extract. The formed film would act as a barrier between the steel and corrosive environment interface and thus preventing and/or stifling corrosion reactions.

The variation in potential vs Saturated Calomel electrode (SCE) with respect to exposure time in different concentration of rosemary extract are depicted in Fig. 4. All the concentrations of extract showed good inhibitory effects towards corrosion. The potential range observed was -468 to -493 in presence as compare to -485 to -504 in absence of corrosion inhibitor. Fig. 4 also showed that all the potential values were remained less negative during the whole exposure period than in control. The decrease in potential value after passage of 9 days could be due to the weakening of corrosive medium by the corrosive products and deposits on the test specimen. The presence of inhibitor shifted the potential more positively than in control.

IV. CONCLUSIONS

From the above presented studies it can be safely concluded that

- The rosemary extract performed as an effective corrosion inhibitor in 0.1 N HCl at ambient temperature.
- The corrosion inhibition action of rosemary extract is concentration dependent.
- The corrosion inhibition is attributed to adsorption of organic compounds on surface of mild steel.

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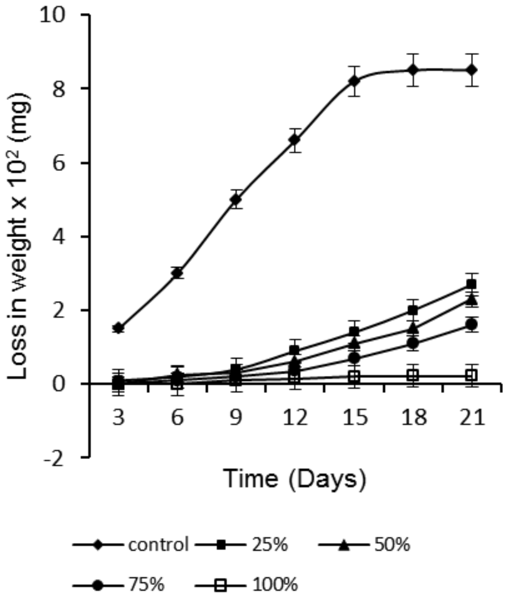

***Figure 1**: Variation in weight loss of mild steel in various concentrations of rosemary extract with passage of time.*

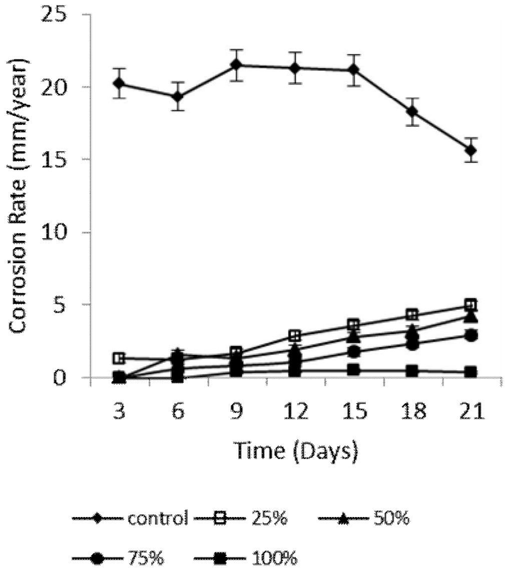

Figure 2: Variation in corrosion rate for mild steel in various concentrations of rosemary extract with passage of time.

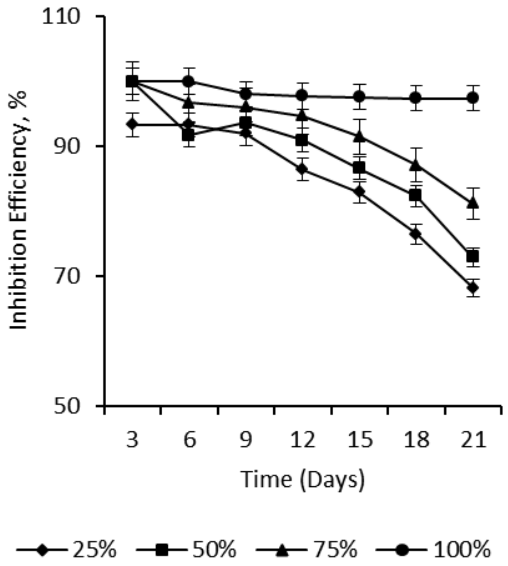

Figure 3: Corrosion inhibition efficiency of various concentrations of rosemary extract with the increase in exposure time for mild steel.

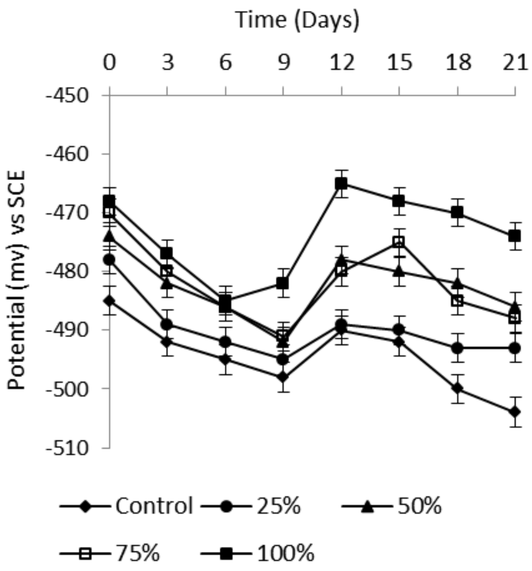

Figure 4: Variation in potential (vs SCE) for mild steel in various concentrations of rosemary extract with passage of time.