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Anti Corrosion Ability of Aqueous Extract of Waste Sakhu (Shorea Robusta) Leaves

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Abstract: ***The corrosion inhibition ability of Sakhu (Sal) leaves (aqueous extract) for mild steel in molar hydrochloric acid solution was investigated by observing the reaction kinetics with time and concentration of the extract at room temperature. The corrosion inhibition efficiency was found to be concentration dependent. Corrosion rate was significantly decreased in presence of the extract and inhibition efficiency increased with increasing the concentration of extract. The results showed an excellent corrosion inhibition property. The decreased corrosion rate was due to adsorption of plant extract on the metal surface that acts as barrier between metal and the medium. The adsorption behavior followed the Langmuir adsorption isotherm. Reaction rate constant and half life of the reaction were also calculated.***

Key Words: **Sakhu, corrosion, inhibitor, mild steel, Langmuir adsorption, mass loss, half life.**

I. INTRODUCTION

Mild steel is extensively used in various industrial applications due to its easy availability, good strength and comparatively low cost. Acid solutions are used in metal finishing like pickling and descaling. Metals are aggressively attacked by acid and a considerable amount of metal loss as corrosion is observed. Chemical corrosion inhibitors are often used for protection of metals in such environment but they are toxic in nature. The use of synthetic inhibitors like chromium, cadmium, and lead based compound are considered as environmentally unsafe, because these elements are heavy metals [1]. Naturally occurring plant extracts have got the best choice because of their non toxic nature. A large number of natural products from various parts of the plant have been reported as prominent corrosion inhibitors, few are extract of Azardiracta indica, flacourtia jangomas, Citrus aurantifolia, Pterocrpus soyauxi, Indian Gooseberry, Ricinus communis,, Black pepper, henna, Capparius deciduas, Kalmegh (andrographis paniculata) and Rosemary extract [2]-[16]. But still there are numerous plants that have not been investigated and reported.

Sakhu (Shorea Robusta) is one of the most common trees found around and nearby area of Gorakhpur, India. The plant has proved its medicinal utility and the leaves are used in many ways such as in making plates, serving food and eatable items etc. The used leaves are often treated as garbage. In the present work corrosion inhibition property of waste Sakhu leaf-extract was investigated in molar solution of HCl for mild steel at 35°C.

II. EXPERIMENTAL METHODS

A. Materials

The mild steel (C 0.2% by weight) sheet was used for weight loss measurements. The coupons of size 2.5×2.5×0.1cm were cut from the sheet. Before use of the coupons they were exposed to pickling solution for removal of rust and then polished on different grade emery papers. The specimens were then washed and degreased with alcohol and acetone.

B. Corrosion Medium

1M HCl solution was prepared using analytical grade concentrated 37% HCl (Merck Products) and double distilled water. This acid solution was used for corrosion analyses.

C. Preparation of Plant Extract

Used and naturally fallen leaves of sakhu plant were collected from Gorakhpur city of U. P., India. The leaves of the plant were washed, dried in air and then kept in an oven maintained at 50°C for constant weight to remove the moisture. Dried leaves were then ground to make powder. 10 g of dried powder of leaves were boiled in 200 mL distilled water with reflux condenser for 3 hours and kept over night. It was filtered after 24 hours.

III. GRAVIMETRIC MEASUREMENTS

A. Effect of concentration

The mass loss studies were carried out at temperature 35°C in 100 ml of blank 1M HCl and test solutions of various concentrations of extract (0.5, 1.0, 1.5, 2.0, 2.5, 3.5 and 5g/l) for 72 hours. At the end of the reaction the specimens were taken out, washed with water, dried with air drier and weighed. Corrosion rates (decrease in weight in gram per cm^2 per hour) were calculated using following expression.

$$\text{Corrosion Rate (CR)}\ (g.cm^{-2}h^{-1}) = \frac{W_1 - W_2}{A \times T}$$

Where, W_1=

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initial weight of coupon, W_2 = weight of coupon after treatment, W_1–W_2 = weight loss (g), A = surface area, T = time in hours

The surface coverage (θ) as a result of adsorption of inhibitor and inhibition efficiency (η%) were calculated from corrosion rate values by using the following equation

$$\textbf{Surface coverage } (\theta) = \frac{CR_B - CR_I}{CR_B}$$

$$CR_B - CR_I$$

$$\eta\ \% = \frac{\qquad\qquad \times 100}{CR_B}$$

Where, CR_B and CR_I are the corrosion rates in absence and presence of the inhibitor respectively. Corrosion of mild steel in HCl is found to be following a first order reaction [3]. The Rate constant and half life ($t_{1/2}$) were calculated using expression

$$k = \frac{2.303\ RT}{t} \log\frac{W1}{W2} \qquad t_{1/2} = 0.693/k$$

IV. RESULTS AND DISCUSSION

The corrosion rate of mild steel in 1M hydrochloric acid solution was studied by weight loss method in blank solution and with various concentration of Sakhu leaf-extract. The variation of corrosion rate, percent inhibition efficiency and surface coverage with increasing concentration is given in table-1. Graphical representation of dependence of corrosion rate and inhibition efficiency with concentration is allocated in figure-1 and 2 respectively. The plots showed that corrosion rate was significantly lowered down in presence of inhibitor and inhibition efficiency increased with increasing the concentration. The surface coverage also increased with increasing concentration. The decreasing corrosion rate and the increasing inhibition efficiency was attributed to the fact that the adsorption of inhibitor on the metal surface. The adsorption of the extract creates a barrier that prevents corrosion [17], [18]. Saponins and phenolic compounds present in sakhu that have oxygen atoms with lone pair electrons may be responsible for adsorption. The values for half life period of the reaction increased with the concentration significantly (figure-4).

S. No.	Inhibitor Conc. g/l	Initial Weight of steel sample g/cm^2	Final Weight of steel sample g/cm^2	Weight loss g/cm^2	Corrosion rate gcm^{-2}h^{-1} ($\times 10^{-4}$)	Surface coverage (θ)	Percent Inhibition Efficiency % η	Rate constant ($k \times 10^{-3}$) (h^{-1})	Half life ($t_{1/2}$) H
1	0	0.2545	0.1609	0.0936	13.00	----	----	6.4	108.3
2	0.5	0.2452	0.1970	0.0482	6.69	0.485	48.5	3.0	231
3	1.0	0.2632	0.2432	0.02	2.78	0.786	78.6	1.1	630
4	1.5	0.2596	0.2511	0.0086	1.24	0.905	90.5	0.46.	1506.5
5	2.0	0.2444	0.2370	0.0074	1.028	0.921	92.1	0.43	1611.6
6	2.5	0.2612	0.2540	0.0072	1.0	0.923	92.3	0.39	1776.9
7	3.5	0.2415	0.2355	0.006	0.83	0.936	93.6	0.35	1980
8	5.0	0.26	0.2548	0.0052	0.72	0.945	94.5	0.28	2475

Table-1: Values of corrosion rates, inhibition efficiency, surface coverage, rate constant and half life at various concentrations

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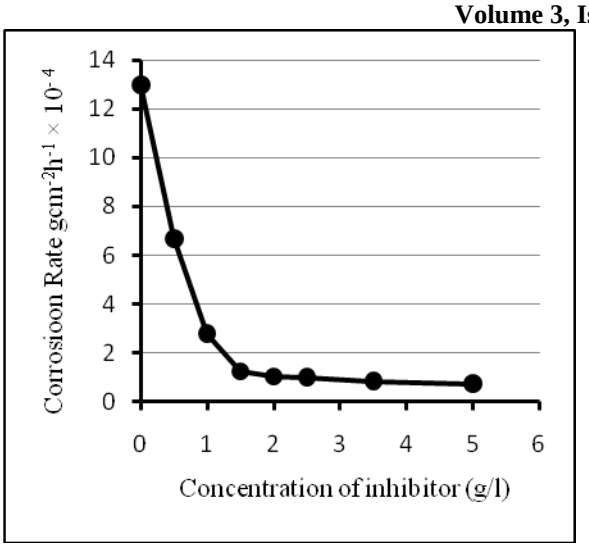

Fig-1: Variation of corrosion rate with concentration of sakhu (g/l) in 1M HCl solution

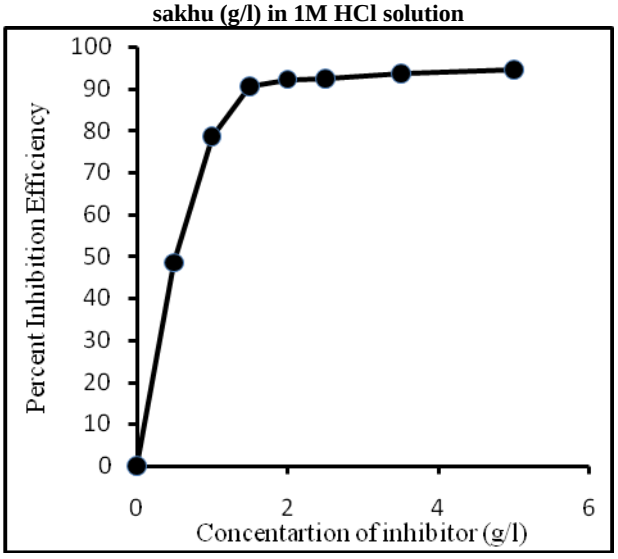

Fig-2: Variation of percent inhibition efficiency with concentration of Sakhu (g/l) in 1M HCl solution

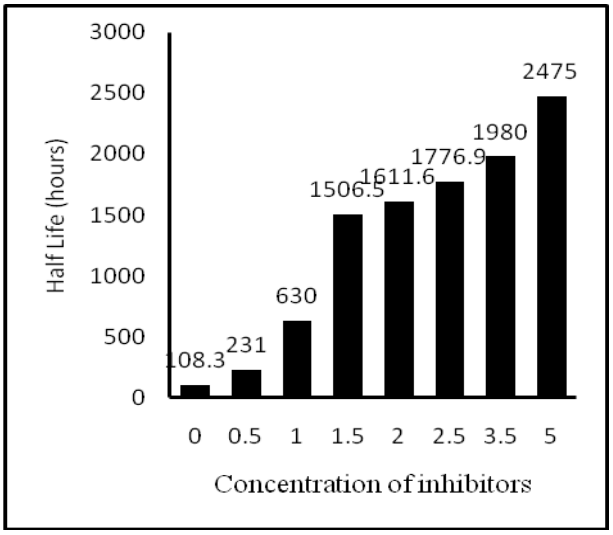

Fig.3: Half life of the corrosion of mild steel in 1M HCl without and with inhibitors

Adsorption isotherms

Adsorption isotherms are used to describe the adsorption process. Langmuir adsorption models can be represented by following equation [19],

$$C/\theta = C + 1/k.$$

Where, c=concentration, θ=surface coverage, k=equilibrium constant.

A plot of C/θ) against C (Figure-4) showed a straight line (R^2= 0.993, approaching unity) indicated that adsorption follows the Langmuir adsorption isotherm.

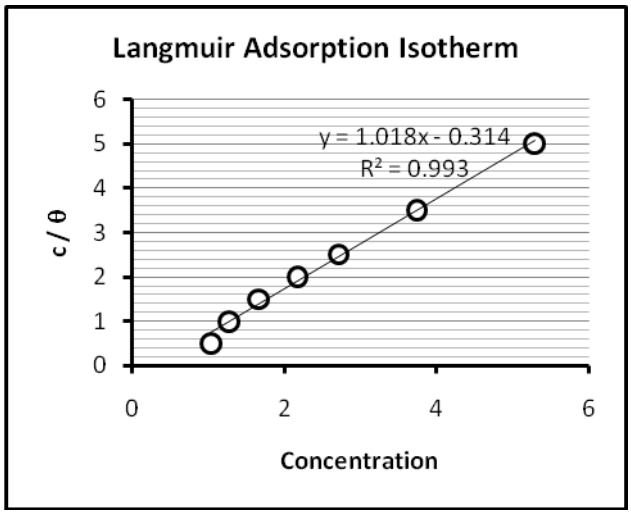

Fig-4: Langmuir Adsorption Isotherm

V. CONCLUSIONS

The results showed that the extract of leaves of Sakhu inhibited the corrosion of mild steel in 1M HCl solution significantly. Inhibition efficiency of Sakhu extract increased with increasing extract concentration. The inhibition activity of Sakhu extract was due to the adsorption activity of the extract which was confirmed by Langmuir adsorption isotherms. Half life of the reaction was found increasing with increasing concentration of extract. Consequently, the Sakhu waste leaves can be used as a potential corrosion inhibitor.

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