

## CORROSION STUDIES OF MILDSTEEL BY ARECA NUT HUSK EXTRACT IN HYDROCHLORIC ACID MEDIUM

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### Abstract

The objective of this study was to investigate the inhibitive action of Areca nut husk extract towards the corrosion of mild steel in 1M HCl solution using mass loss and electrochemical techniques. The results indicate that the inhibitive action of the extract is dependent on the concentration of the extract. The inhibition capacity of this extract may be attributed to the presence of different phytochemical constituents present in the extract. A suitable mechanism has been proposed for the present study. Potentiodynamic polarization and impedance studies reveal that the system follows mixed mode of inhibition. Inhibition efficiency obtained from mass loss and electrochemical studies are quite comparable.

**Keywords:** Corrosion inhibition, Mild steel, Areca nut husk extract.

### Introduction

Corrosion has been the subject of scientific study for more than 150 years. It is a naturally occurring phenomenon commonly defined as the deterioration of a material (usually a metal) or its properties because of a reaction with its environment. Like other natural hazards such as earthquakes or severe weather disturbances, corrosion can cause dangerous and expensive damage to everything from pipelines, bridges, and public buildings to vehicles, water and wastewater systems, and even home appliances. Unlike weather-related disasters, however, there are time-proven methods to prevent and control corrosion that can reduce or eliminate its impact on public safety, the economy, and the environment. The use of inhibitors is one of the most practical methods for protection against corrosion, especially in acidic media<sup>1</sup>. Inhibitors play an important role in controlling corrosion of metals<sup>2</sup>. Such investigation is of much importance because in addition to being environmentally friendly and ecologically acceptable, plants products are inexpensive, readily available and renewable sources of materials.

The use of natural products as corrosion inhibitors have been widely reported by several authors<sup>3-11</sup>. Among plant materials tested in our laboratory include sprouted seeds of *Phaseolus aureus*<sup>12</sup>, seed extract of *Cyamopsis tetragonoloba*<sup>13</sup>, Petiole Extract of *cocos nucifera*<sup>14</sup>, leaves extract of *Gossipium hirsutum*<sup>15</sup>, juice of *Prunus cerasus*<sup>16</sup>. Green inhibitors displaying substantially improved environmental properties will be the inhibitors most widely used in future. Hence, the present study has been effectuated to investigate the

action of *Areca nut husk extract* on corrosion inhibition of mild steel in dilute hydrochloric acid medium.

### Experimental

#### Preparation of Samples

Mild steel (MS) specimens of the following chemical composition in wt % - carbon 0.143, manganese 0.271, silicon 0.041, phosphorus 0.035, sulphur 0.030, chromium 0.002, molybdenum 0.018, nickel 0.006 and Fe 99.454, were used for the entire study. For weight loss study, MS specimens of size 1 x 5 cm<sup>2</sup> were used. MS specimens with an exposed area of 1 cm<sup>2</sup> were used for electrochemical study. The specimens were mechanically polished, degreased, dried and stored in a desiccator.

#### Preparation of plant extract

25 g of Areca nut husk was refluxed with 500 mL of 1M HCl for 3 hours and kept overnight. The cooled extract was filtered and made up to 500 ml (5% extract). From the stock solution, test solutions were prepared in the concentration range 0.1%-0.8%.

#### Weight loss method

Pre weighed test pieces were immersed in triplicate in 100 mL of the solution containing various concentration of the inhibitor and in the blank acid for a predetermined time period. The test specimens were removed and then washed with de-ionised water, dried and reweighed. The experiments were performed for various concentrations and at different intervals of time.



### Electrochemical measurements

Potentiodynamic curves and Nyquist plots were recorded using computerized Solartron model 1284. In this setup a platinum electrode, calomel electrode and MS specimens were used as auxiliary, reference and working electrodes respectively which were immersed in acidic medium in the presence and absence of different concentration of the inhibitor.

### Results and Discussion

#### Effect of concentration and Time

Table 1 depicts the variation of inhibition efficiency (IE) with respect to concentration of the inhibitor. It can be inferred that as the dosage of inhibitor increased, the IE was found to increase. This behaviour can be attributed to the increase in surface area covered by the adsorbed molecules of the extract with increased concentration<sup>17</sup>. A maximum of 92.9% was obtained at 0.8% concentration of the extract.

hours. The plot indicates the increase of inhibition efficiency with time as shown in Fig.1

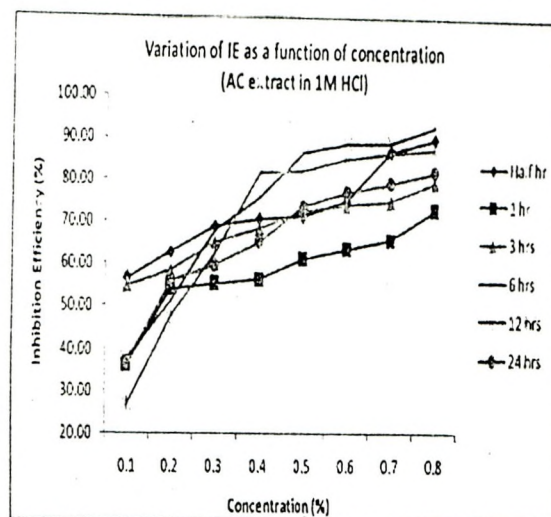


Fig.1 : Variation of IE as a function of concn

**Table-1:** Effect of concentration and time on corrosion inhibition of mild steel in Areca nut husk extract in 1M HCl

S. No	Concn of inhibitor (%)	Immersion Time(in hours)					
		0.5	1	3	6	12	24
1.	0.1	56.52	36.47	54.90	37.64	26.93	36.75
2.	0.2	62.73	54.12	58.33	51.09	47.46	56.11
3.	0.3	68.94	55.29	65.20	67.96	62.55	59.61
4.	0.4	70.81	56.47	68.63	75.75	81.77	65.21
5.	0.5	71.43	61.18	72.55	86.54	82.38	73.79
6.	0.6	75.16	63.53	74.02	88.87	85.10	76.98
7.	0.7	86.96	65.88	75.00	89.07	86.56	79.27
8.	0.8	90.06	72.94	79.41	92.90	87.50	82.08

To investigate the effect of inhibition with exposure time, experiments were carried out at various time intervals. It is clear from Table 1 that, as the time of immersion increases from 1 hour to 6 hours, the protection efficiency increases from 72.9% (0.8% concentration at 1 h) to 92.9% (0.8% concentration at 6 h). After 12 hours there is a slight decline in IE to 82% at 24

#### Potentiodynamic polarization studies

From potentiodynamic studies, the polarization curves obtained in the presence and absence of Areca nut husk extract are depicted in the fig.2 & table.2 and the results indicate a considerable reduction in  $I_{corr}$  values in the presence of the inhibitor. This confirms the inhibitive nature of the nut husk and also

**Table-2:** Electrochemical Potentiodynamic polarization and Impedance studies of mild steel in the presence of Areca nut husk extract in 1M HCl

S.No	Conc. of inhibitor in (%)	$E_{corr}$ mV/SCE	$I_{corr}$ mA/cm <sup>2</sup>	$b_a$ mV/dec	$b_c$ mV/dec	IE (%)	$R_p$ Ohm/cm <sup>2</sup>	IE (%)	$R_{ct}$ ohm cm <sup>2</sup>	IE (%)
1	Blank	490.6	0.0442	113.2	98.2	-	3.776	-	18.723	-
2	0.1	488.1	0.0036	98.7	83.6	91.86	10.693	64.68	23.155	19.14
3	0.2	482.1	0.0033	96.1	89.1	92.53	11.499	67.16	25.122	25.47
4	0.4	478.3	0.0031	102.7	107.4	93.00	18.273	79.33	32.034	41.55
5	0.6	477.7	0.0027	127.3	128.5	93.84	24.851	84.80	34.14	45.16
6	0.8	471.3	0.0025	129.8	143.1	94.32	40.706	90.72	39.074	52.08



the adsorption of inhibitor on metal surface. The values of IE are found to be increasing with increase in concentration of the inhibitor.

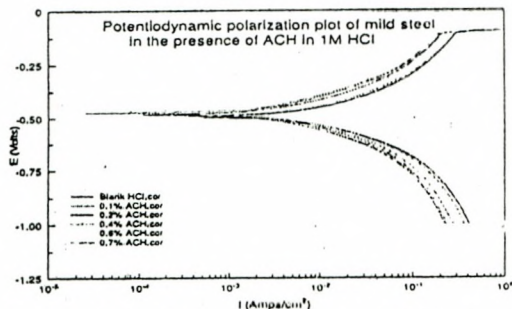


Fig: 2 Potentiodynamic polarization of mild steel in the presence of Areca nut husk

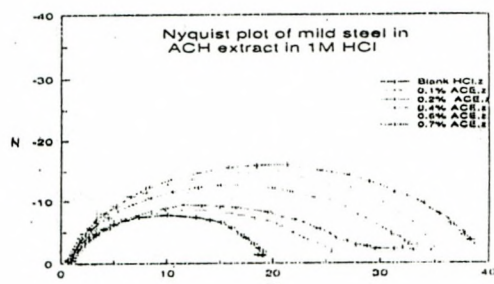


Fig: 3 Impedance curves of mild steel in the presence of Areca nut husk

Around 94.3% of inhibition was obtained with 0.8% concentration. No significant change in  $E_{corr}$  values in the presence of inhibitor indicates the mixed nature of the inhibitor.

Tafel constant  $b_a$  and  $b_c$  are found to be changing with the concentration of the inhibitor.  $R_p$  values increase with increase in concentration of Areca nut husk extract. Polarization curves obtained in the presence of the inhibitor also reveals that the Areca nut husk extract is controlling the metal dissolution reaction as well as hydrogen evolution reaction. From the results obtained that the husk extract of Arecanut actas as mixed inhibitor

#### Electrochemical impedance measurements

The Nyquist representation of electrochemical impedance spectroscopic values for mild steel in 1 M HCl containing different concentrations of Areca nut husk extract is presented in Fig. 3. The existence of the depressed nature of the semicircle with its centre below the x axis is the characteristic of solid electrodes and is attributed to the increased micro-roughness of the surface and other inhomogeneties of solid electrodes during corrosion. The diameter of the se nicircle gives the charge transfer resistance  $R_{ct}$  equivalent to the polarization resistance  $R_p$ , which is inversely

proportional to corrosion rate.  $R_{ct}$  values increase with increase in the concentration of Areca nut husk extract.

#### Mechanism of Inhibition

The mechanism of inhibition of corrosion is generally believed to be due to formation and maintenance of a protection film on the metal surface. On a weight basis, the husk is 60 to 80% of the whole fruit. The husk fiber itself is mainly constituted of cellulose. The major constituents of arecanut are pectin at 1.5-3.6%, protopectine at 1.5-2.1%, hemi cellulose at 35-65.8%, lignin at 13-26%, furfuraldehyde at 18.8% and ash at 4.4% and moisture content varying from 91% when very tender to 74 % when ripe. The polar units in hetero atoms like oxygen present in the extract is acting as reaction centre for adsorption process.

#### Conclusion

Husk extract of Areca nut acted as an effective corrosion inhibitor for mild steel in 1M HCl affording a maximum of 93% IE at 0.8% concentration. Electrochemical studies confirmed the mixed mode of inhibition for the corrosion of mild steel in 1M HCl in the presence of Areca nut husk extract. Inhibition efficiency by various techniques is quite comparable.

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