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Inhibition of the Corrosion of Iron in Citric acid solutions by Aqueous extract of Fenugreek seeds

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Abstract

Gravimetric method has been used to study the effect of Aqueous extract of Fenugreek seed (AEFS) on the corrosion of Iron in Citric Acid solutions. The percentage inhibition increased with the increase of the concentration of the inhibitor in the studied range. The inhibition efficiency decreases with increase in temperature. The adsorption of AEFS on Iron surface obeys the Langmuir adsorption isotherm and the kinetic parameters for the adsorption of this inhibitor on the metal surface are calculated by using the Arrhenius equation. The Aqueous extract of Fenugreek seeds is observed as a good corrosion inhibitor in Citric Acid solutions at experimental conditions.

Key words : Corrosion, Inhibitors, Iron, Fenugreek, Gravimetric, Langmuir adsorption isotherm.

Introduction

Corrosion is an important problem in all practical uses of metals in automobiles, bridges, buildings, machinery, pipelines, ships, indeed in most of the works of man. The most common approach to the prevention of corrosion is to cover the metal surface with a protective coating eg. paint, plastic, ceramic or an electroplated layer of a passive metal such as chromium, nickel or tin. A corrosion inhibitor works by decreasing the rate of metal oxidation, by decreasing the rate of oxygen (or water) reduction or by shifting the surface potential into the passive region[1]. The plants are the great chemical factories, supplying us variety of chemicals including corrosion inhibitors. Numerous plant products such as Henna, Lawsonia inermis[2], Rosmarinous officinalis L.[3], Carica papaya[4], Cordia latifolia

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and Curcumin[5], Date palm, Phoenix dactylifera, Zea mays[6], Nypa Fruticans Wurmb[7] etc. are observed as good inhibitors in different aggressive media.

The main aim of present work is to find out corrosion inhibition efficiency of Aqueous extract of Fenugreek seeds at iron surface in Citric acid solutions. The effect of temperature is also recorded.

Experimental

For the weight loss determination, cylindrical iron specimen of Tata Tiscon™ 5 cm. in length and 1.2 cm in diameter were taken for recording their constant weight. These specimen were abraded with a series of emery paper then degreased with acetone, washed thoroughly with doubly distilled water and finally dried in hot air. Stock solution of AEFS was prepared by boiling 4g of dried grounded fenugreek seeds in 1000 ml of de-ionized water for 1 hour. The extract was left all night and then filtered and completed to 1000 ml. by de-ionized water. 1 M Citric acid solution was used as aggressive solution. Weight loss of iron specimen was determined in absence and presence of various concentrations of AEFS. The employed concentration range of AEFL was of 0.5 – 10 v/v%. The immersion time of iron specimen was 1 hour. After completion of immersion time, the specimen was taken out, washed, dried and again weighed accurately. The experiments were repeated at different inhibitor concentration and different temperatures.

Results and Discussion

The value of corrosion rate ($\rho_{corr.}$) was calculated from the following equation :

$$\rho_{corr}.(g.cm.^{-2}\ min^{-1}) = \frac{m_1 - m_2}{A.t.} \quad (1)$$

where m_1 and m_2 are the masses of the specimen before and after corrosion, A is the total area of the specimen and t is the corrosion time.

Table 1: represents the corrosion rates of iron specimen in 1 M Citric acid solution in absence and presence of different concentrations of AEFS at different temperatures. A remarkable decrease in iron corrosion rate was observed with the addition of increasing amount of AEFS. It is clear from Table.1 that corrosion rate of iron in 1 M Citric acid in absence and presence of AEFS obeys the Arrhenius type reactions as it increases with rising solution temperature. Kinetic parameters K (rate constant) and B (reaction constant) can be calculated by this equation.

$$\log \rho_{corr.} = \log k + B \log C_{inh.} \quad (2)$$

where K is the rate constant and equal to $\rho_{corr.}$ at inhibitor concentration of unity, B is the reaction constant which is a measure for the inhibitor effectiveness and $C_{inh.}$ is the v/v% (ml/100ml) concentration of the AEFS. Figure 1 represents the curves of log $\rho_{corr.}$ verses log $C_{inh.}$ at various studied temperature. The straight lines show that the Kinetic parameters (K and B) are calculated by Eq. (2) and listed in Table 2 :

Table 1. Iron corrosion rates in 1 M citric acid in absence and presence of different concentrations of AEFS at different temperatures

$C_{inh.}$	$\rho_{corr.}$ x10^{-6}(gcm^{-2} min^{-1})			
v/v%	30^0C	40^0C	50^0C	60^0C
0.0	6.9	11.7	22.3	52.3
0.5	4.5	9.3	18.2	47.4
1.0	4.1	8.4	16.4	45.7
2.0	3.3	7.2	14.7	36.3
5.0	3.1	6.0	13.9	31.5
10.0	2.5	5.2	12.5	25.1

Table 2. Kinetic parameters for the corrosion of Iron in 1 M Citric Acid containing AEFS at different temperatures.

Temperature	Kinetic Parameters	
(^{0}C)	B	k x10^{-6}(g cm^{-2} min^{-1})
30^0	-0.2333	0.4797
40^0	-0.1833	0.5023
50^0	-0.1666	0.6622
60^0	-0.20000	0.4571

Effect of temperature on inhibition efficiency IE (%) :

With the calculated corrosion rates listed in Table 1 the inhibition efficiency for iron corrosion in Citric acid in presence of various concentrations of AEFS and at different temperatures was obtained from the following equation :

$$IE\% = \left(\frac{\rho^0_{corr.} - \rho_{corr.}}{\rho^0_{corr.}}\right) x100 \qquad (3)$$

Where $\rho^0_{corr.}$ & $\rho_{corr.}$ are the corrosion rates of iron in absence and presence of certain concentration of AEFS respectively. Table 2 illustrates the variation of IE (%) with AEFS concentration at different temperatures in 1 M Citric acid. The obtained data in Table 2 reveals that the inhibition efficiency increases with an increase in the inhibitor concentration. This suggests that the inhibitor species are

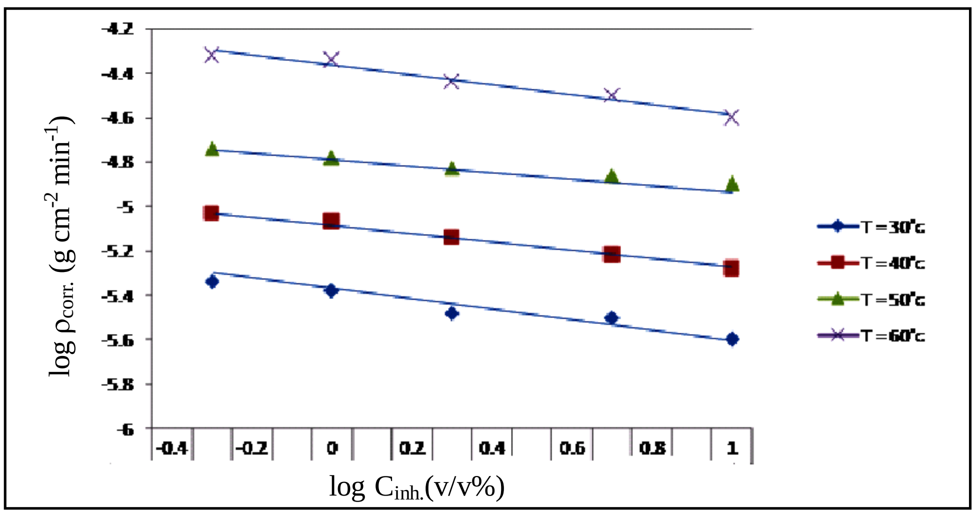

Figure 1. Variation of log $\rho_{corr.}$ with log $C_{inh.}$ for iron in 1 M Citric acid in presence of different concentrations of AEFS at different temperatures.

adsorbed on the iron/ solution interface where the adsorbed species mechanically screen the coated part of the metal surface from the action of the corrosive medium[8]. It can be seen that the IE (%) reaches 63.76% at 303K.

Table 3. Inhibition efficiencies of AEFS at different concentrations & temperatures in 1 M Citric Acid

$C_{inh.}$v/v%	IE (%)			
	30^0C	40^0C	50^0C	60^0C
0.5	34.78	20.51	18.39	09.36
1.0	40.57	28.20	26.45	12.62
2.0	52.17	38.46	34.08	30.59
5.0	55.07	48.47	37.66	39.77
10.0	63.76	55.55	43.95	52.00

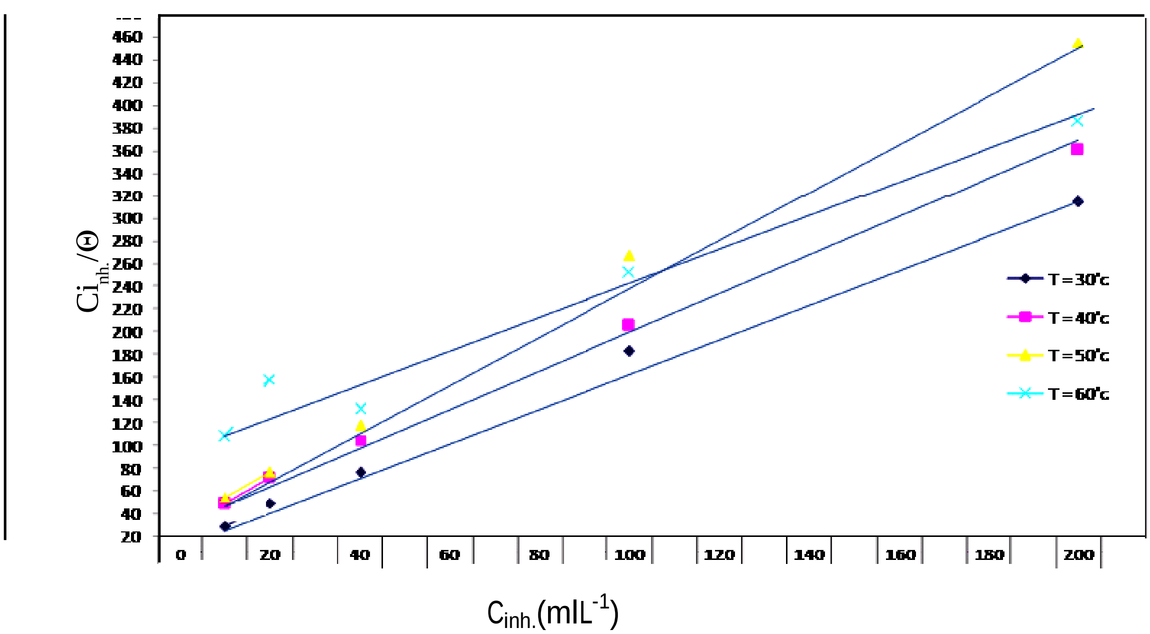

Figure 2. Langmuir adsorption isotherm of AEFS on iron surface in 1M Citric acid.

Adsorption isotherms: Adsorption plays an important role in the inhibition of metallic corrosion by inhibitors. Many investigators have used the Langmuir adsorption isotherm to study inhibitors characteristics[9].

Langmuir adsorption isotherm –

$$\frac{C_{inh.}}{\Theta} = \frac{1}{K_{e.c.a.}} + C_{inh.} \qquad (4)$$

where $C_{inh.}$ is the inhibitor bulk concentration in ml L^{-1} . $K_{e.c.a.}$ (ml^{-1} L) is the equilibrium constant of adsorption and Θ is the degree of surface coverage and is equal to IE%/100. The degree of surface coverage can be plotted as a function of the concentration of the inhibitor under test. A straight line is obtained as a result (Fig. 2)

The primary mechanism in the process of inhibition is adsorption of inhibitor species on the metal surface.

Conclusion

The Aqueous fenugreek seeds extract was found to be a good inhibitor for iron in 1 M Citric Acid solution with inhibition efficiency reaching upto 63.76% at room temperature.

The rate of corrosion of iron in 1 M Citric Acid is observed as function of the concentration of AEFS under experimental conditions. This rate is decreased as the concentration of AEFS is increased. The inhibition efficiency decreases with increase in temperature indicating that physical adsorption was the predominant inhibition mechanism because the quantity of adsorbed inhibitor decreases with increasing temperature. The aqueous extract of Fenugreek seeds is a good, green, eco-friendly and cheaper corrosion inhibitor for iron in 1 M Citric Acid solution

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