Int. J. Chem. Sci.: 10(2), 2012, 817-823
ISSN 0972-768X
www.sadgurupublications.com

CORROSION INHIBITION STUDIES AT IRON SURFACE IN ACETIC ACID SOLUTIONS BY AQUEOUS EXTRACT OF *FENUGREEK* LEAVES

ALKA SINGH[*] and S. KALPANA

Electrochemistry & Environmental Chemistry Lab, Department of Chemistry Government College,
KOTA – 324001 (Raj.) INDIA

ABSTRACT

Gravimetric method was used to study the effect of aqueous extract of *Fenugreek* leaves (AEFL) on the corrosion of iron in CH_3COOH solutions at different temperatures. The inhibition efficiency of AEFL increases with increase in inhibitor concentration and the adsorption of AEFL on iron surface obeys the Langmuir adsorption isotherm. The aqueous extract of *Fenugreek* leaves is observed as good potential corrosion inhibitor in acetic acid solutions at experimental conditions.

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

INTRODUCTION

Corrosion consists of the spontaneous oxidation of metals, usually by atmospheric oxygen but also by water or atmospheric pollutants such as SO_2[1]. Corrosion inhibitors are chemical compounds, which reduce the rate of corrosion at the metal or alloy surfaces. Large number of organic compounds have been studied and are being studied to investigate their corrosion inhibition potential. All these studies reveal that organic compounds especially those with N, S and O showed significant inhibition efficiency. However a certain proportion of these compounds is not only expensive but also shows some toxicity to living beings[2]. Several efforts have been made using nontoxic and environmental friendly corrosion preventive practices and the use of green corrosion inhibitors is one of them[3]. The plants are the great chemical factories, supplying us variety of chemicals including corrosion inhibitors. Numerous plant products such as *Henna*, *Lawsonia inermis*[4], *Rosmarinous*

---

[*] Author for correspondence; E-mail: alkasingh.1974@yahoo.com, anushrishri@rediff.com,
Mo.: +919784677112, +919461961161

officinalis L.[5], *Carica papaya*[6], *Cordia latifolia* and *Curcumin*[7], *Date palm*, *Phoenix dactylifera*, *Zea mays*[8], *Nypa Fruticans Wurmb*[9] 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 leaves at iron surface in CH_3COOH solutions at different temperatures.

Fenugreek is an annual plant widely cultivated for both medicinal and culinary uses. It contains a wide variety of N-containing compounds (e.g. amino acids, amines, quaternary ammonium of N-heterocyclic compounds, etc.). Fenugreek leaves are rich in ascorbic acid, beta-carotene, xanthophylls, choline and methionine[10]. Among these choline and methionine alkaloids play an important role in the corrosion inhibition of iron in 1M CH_3COOH solutions[11].

EXPERIMENTAL

For the weight loss determination, cylindrical iron specimen of Tata Tiscon$^{\mathbf{TM}}$ iron 5 cm in length and 1.2 cm in diameter were taken. These specimens were abraded with a series of emery paper then degreased with acetone, washed thoroughly with doubly distilled water and finally dried in hot air for recording their constant weight. Stock solution of AEFL was prepared by boiling 4 g of dried grounded fenugreek leaves 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 CH_3COOH solution was used as aggressive solution. Weight loss of iron specimen was determined in absence and presence of various concentrations of AEFL. 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

Effect of temperature on iron corrosion rates

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

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

where m_1 and m_2 are the masses of the specimen in aggressive media without inhibitor and in presence of inhibitor. 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 CH_3COOH solution in absence and presence of different concentrations of AEFL at different temperatures. A remarkable decrease in iron corrosion rate was observed with the addition of increasing amount of AEFL. It is clear from Table 1 that corrosion rate of iron in 1 M CH_3COOH in absence and presence of AEFL 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.

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

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/100 mL) concentration of the AEFL. Fig. 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.

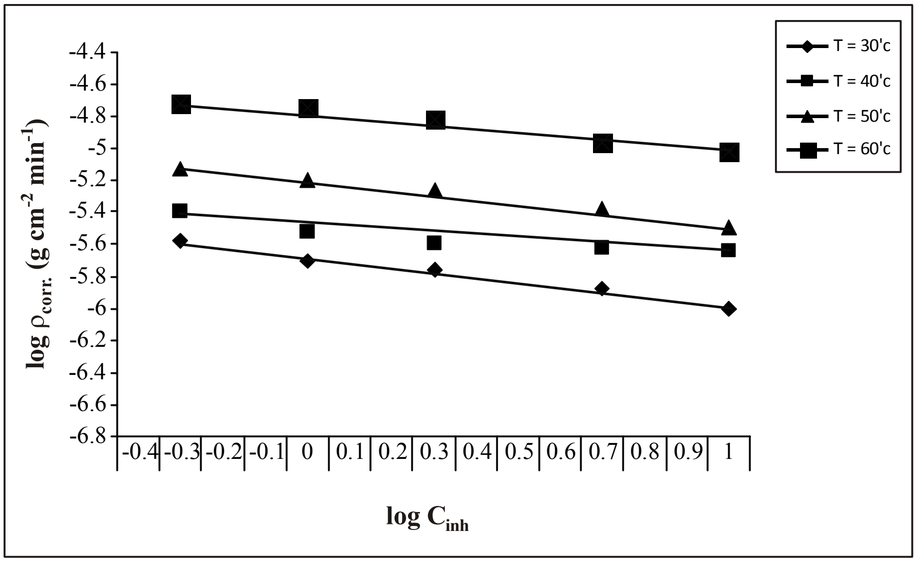

Fig. 1: Variation of log $\rho_{corr.}$ with log $C_{inh.}$ for iron in 1 M CH_3 COOH in presence of different concentrations of AEFL at different temperatures

Table 1: Iron corrosion rates in 1 M CH_3COOH in absence and presence of different concentrations of AEFL at different temperatures

$C_{inh.}$ v/v%	ρ_{corr}. X 10^{-6} (gcm^{-2} min^{-1})			
	30°C	40°C	50°C	60°C
0.0	4.5	6.5	10.1	24.5
0.5	2.6	4.0	7.5	19.2
1.0	2.0	3.0	6.2	18.0
2.0	1.7	2.5	5.4	15.2
5.0	1.3	1.8	4.1	11.2
10.0	1.0	1.6	2.5	9.7

Table 2: Kinetic parameters for the corrosion of Iron in 1 M CH_3COOH containing AEFL at different temperatures

Temperature (°C)	Kinetic Parameters B	k x 10^{-6} (g cm^{-2} min^{-1})
30^0	- 0.3011	0.3162
40^0	- 0.3403	0.2884
50^0	- 0.2378	0.3631
60^0	- 0.2341	0.4365

Effect of temperature on inhibition efficiency IE (%)

With the calculated corrosion rates listed in Table 1 the inhibition efficiency for iron corrosion in CH_3COOH in presence of various concentrations of AEFL and at different temperatures was obtained from the following equation:

$$\text{IE\%} = \left(\frac{\rho^0_{corr.} - \rho_{corr.}}{\rho^0_{corr.}}\right) \text{x} 100 \qquad \ldots(3)$$

where $\rho^0_{corr.}$ & $\rho_{corr.}$ are the corrosion rates of iron in absence and presence of certain concentration of AEFL respectively. Table 2 illustrates the variation of IE (%) with AEFL concentration at different temperatures in 1 M CH_3COOH. The obtained data in Table 3 reveal that the inhibition efficiency increases with an increase in the inhibitor concentration. This suggests that the inhibitor species are 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[12]. It can be seen that the IE (%) reaches 77.77% at 303 K.

Table 3: Inhibition efficiencies of AEFL at different concentrations and temperatures in 1 M CH_3COOH

$C_{inh.}$ v/v%	IE (%)			
	30°C	40°C	50°C	60°C
0.5	42.22	38.46	25.74	21.63
1.0	55.55	53.84	38.61	26.53
2.0	62.22	61.53	46.53	37.95
5.0	71.11	63.07	59.40	54.28
10.0	77.77	64.61	69.31	60.40

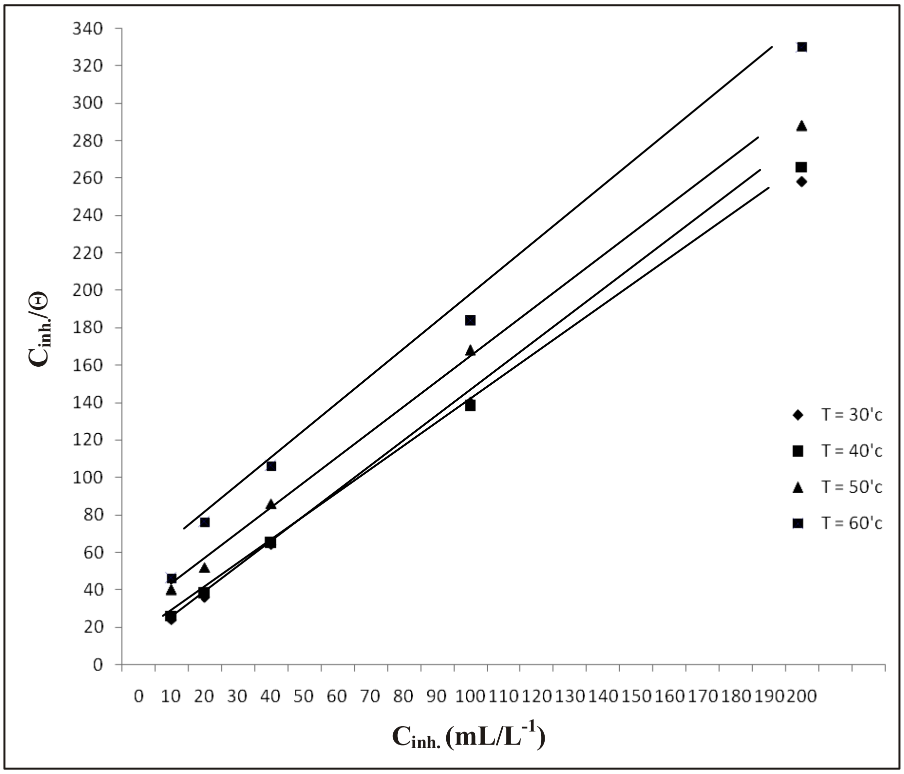

Fig. 2: Langmuir adsorption isotherm of AEFL on iron surface in 1M CH_3COOH

Adsorption isotherms

Adsorption plays an important role in the inhibition of metallic corrosion by inhibitors. Many investigators[13] have used the Langmuir adsorption isotherm to study inhibitors characteristics.

Langmuir adsorption isotherm –

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

where $C_{inh.\,/\,\Theta}$ 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* leaves extract was found to be an efficient inhibitor for iron in 1 M CH_3COOH solution with inhibition efficiency reaching upto 77.77% at room temperature.

The rate of corrosion of iron in 1 M CH_3COOH is observed as function of the concentration of AEFL under experimental conditions. This rate is decreased as the concentration of AEFL 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* leaves is a good, green, eco-friendly and cheaper corrosion inhibitor for iron in 1 M CH_3COOH solution.

ACKNOWLEDGEMENT

The authors are thankful to the Head of Chemistry Department and Principal, Government College, Kota for providing necessary laboratory facilities.

REFERENCES

1. P. H. Rieger, Electrochemistry, Prentice-Hall International Editions, New Jerrsy (1987) p. 423.

2. P. B. Raja and M. G. Sethuraman, Mater Lett., **62(1)**, 113-116 (2008).
3. K. Anuradha, R. Vimla, B. Narayanswamy, J. Arockia Selvi and S. Rajendran, Chem. Eng. Comm., **195**, 352 (2008).
4. H. Al-Sehaibani, Mat.-wiss u, Werkstofftech, **31(12)**, 1060-1063 (2000).
5. M. Kliskic, J. Radosevic, S. Gudic and V. Katalinic, J. Appl. Electrochem., **30(7)**, 823-830 (2000).
6. P. C. Okafor and E. E. Ebenso, Pigments Resin Technol., **36(3)**, 134-140 (2007).
7. I. H. Farooqi, A. Hussain and P. A. Saini, Anti-Corros. Methods M., **46(5)**, 328-331 (1999).
8. H. H. Rehan, Mat.-wiss u, Werkstofftech, **34(2)**, 232-237 (2003).
9. K. Orubite-Okorosaye and N. C. Oforka, Materials Letters, **58(11)**, 1768-1772 (2004).
10. www.swsbm.com/Constituents/constituentsQ-Z.html.
11. M. A. Abdel Rahim, H. B. Hassan and M. W. Khalil, Mat.-wiss., u. Werkstofftech., **28**, 198 (1997).
12. E. A. Noor, Intl. J. Electrochem., **2**, 996-1017 (2007).
13. I. Langmuir, J. Amer. Chem. Soc., **39**, 1848 (1947).

Revised : 18.04.2012 *Accepted : 20.04.2012*