JAMUN EXTRACT AS CORROSION INHIBITOR FOR IRON METAL IN SULPHURIC ACID MEDIUM

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Abstract

Plant extracts have developed into an essential renewable resource and environmentally benign for many applications such as corrosion inhibition. A 0.5M H_2SO_4 stock solution was mixed with the Jamun extract for increased effectiveness, and the Gravimetric Method was used to measure the effects of different concentrations. FTIR analysis was used to characterise the plant extracts, SEM proved that an iron surface protective layer had formed, and other methods, including UV-Visible investigations and weight-loss analysis, were also employed. The inhibition efficiency was evaluated at various temperatures, and results showed that it was around 93.6% at 900 ppm of inhibitor solution in H_2SO_4 acidic medium at 25ºC. We conclude that Jamun Extract exhibits promising results as an eco-friendly and effective inhibitor of iron corrosion.

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Introduction

Many industries employ iron (Fe), however while doing so, it frequently comes into contact with corrosive environments such acidic, alkaline, and salt environments [1, 2]. According to several forms of corrosion inhibitors, the ones with S, P, O, N, and multiple bonds in their structures are the greatest at defending metals employing organic inhibitors. [3] The search for inexpensive and reliable inhibitors has therefore captured the interest of the researchers. Recent research on corrosion protection has centred on the use of safe and efficient inhibitors, also known as "green corrosion inhibitors" [4]. Various plant components, including roots, seeds, leaves, stems, and fruits, were used to produce the ecosystem-safe corrosion inhibitors.

Numerous studies have examined the effectiveness of other plants' aqueous extracts as green corrosion inhibitors, including Robinia pseudoacacia, which demonstrated 93.5% IE at 1800 ppm[5], the potency of bilimbi fruit, which demonstrated 79.84% IE at 800 ppm[6,] the green eucalyptus leaf, which demonstrated 88% IE at 800 ppm[7], the negro pepper, which demonstrated 97.18% IE[8], Adansonia digitata Show 74.5% IE[9], Chamaerops humilis Show 88.5% IE[10], Moringa oleifera Show 80% IE[11], grape seed Show 88% IE at 300 ppm [12], Mangifera indica Show 99% IE[13], Nephelium lappaceum Show 97% IE[14], *Polygonatum odaratum* Show 87.6% IE[15], *Flacourtia Jangomas* Show 98% IE at 5% v/v [16], Cistus monspeliensis Show 92% IE [17], Oil palm empty Show 95.8% IE[18], kola leaf Show 78.6% IE[19], *Conocarpus* Erectus Show 91.1% IE at 300 ppm[20], *Morinda citrifolia* Show 59% IE[21], *Theobroma cacao* Peel Show 92.08% IE[22], *Pomegranate* Peel Show 67.42% IE at 0.5 g/L [23], *Cassia auriculata* Show 74.7% IE[24], Citrus Sinensis Seeds Show 90.56% IE at 30 C[25], Prunus persica Show 87% IE[26], Calendula officinalis Show 94.67% IE [27], *Alchornea Cordifolia* Show 80.68% IE at 70 C[28], *Cucurbita* Maxima Show 98% IE[29], *Mimosa pudica* leaves Show 77.3% IE[30], *Syzygium aromaticum* Show 93.25% IE[31], *Jatropha Curcas* Show 77.1% IE[32], *Argemone Mexicana* Show 92.5% IE for 500 mg /L extract concentration [33], *Veronia Amygdalina* Show 34.7% IE [34], The objective of this study is to examine the effects of a new and inexpensive green corrosion inhibitor in jamun extract on iron in a 0.5M H_2SO_4 solution by using the weight loss method, UV-Visible, SEM, and FTIR techniques.

Materials and Methods

Sample collections

Preparation of Iron Specimen

The iron used for this investigation was mechanically chopped into sheets of 2.5 cm by 2.5 cm by 0.2 cm. To encourage rapid corrosion, the iron's surface was polished with various abrasive paper grades. After being cleaned with deionized water, the samples were dried using paper towels.

Preparation of Jamun Extract

Jamun was acquired in north Sudan or north Africa. After being washed, it was powdered after drying at room temperature for roughly 4 weeks. After being mixed for 3 hours at 80 °C with 15g of jamun powder and 500 ml of deionized water, the extract was filtered.

Preparation of inhibitor solution

Lotus Enterprises Chemicals provided 500 ml of 98% 1 M H_2SO_4, which was used to make 0.5 M from H_2SO_4 using distilled water. Jamun extract and 0.5 M H_2SO_4 were then combined to create solutions with various concentrations (0, 300, 600 and 900 ppm).

Gravimetric study

The ASTM G31-72 method of immersion testing at various temperatures for 24 hours was used to determine the inhibition effectiveness and corrosion rate; We cleaned and dried the samples before and after immersion, and the weight difference between the final weight and the starting weight was calculated using the relation below. [34];

$$WL= WIn -WFn \quad (1)$$

FTIR spectroscopy uses the inhibitor solution and the taken powder on a Shimadzu spectrophotometer in the spectral range of 500-4000 1/cm.

Spectroscopy in the ultraviolet data was acquired for UV analysis by utilising a Adsorption spectrophotometer with a 200-950 nm wave length, the UV 1800 absorption spectro photo meter, and the inhibitor's adsorption behaviour in 0.5 M H_2SO_4.

A deteriorated surface SEM analysis was used to investigate the impact of 0.5 M H_2SO_4 solutions on the surface morphology. This was done by obtaining SEM pictures after the corrosion test.

Adsorption isotherm (Frumkin, Freundlich, Langmuir, Temkin) has various variations, this might be applied to comprehend how inhibitor chemicals interact with MS surfaces [35,38].

Results and Discussion: -

Gravimetric study:

The following expression can be used to compute the corrosion rate using the weights before and after the corrosion test at various inhibitor proportions. [36,37].

$$C_R = \frac{K \times W}{A \times t \times \rho} \quad (1)$$

Where, C_R- corrosion rate (mmpy), W-weight loss of Iron substrates (g), ρ - density (g/cm^3), t-immersion time in hours.

The following equations can be used to calculate the surface coverage value and corrosion inhibition efficiency using the weight-loss approach.

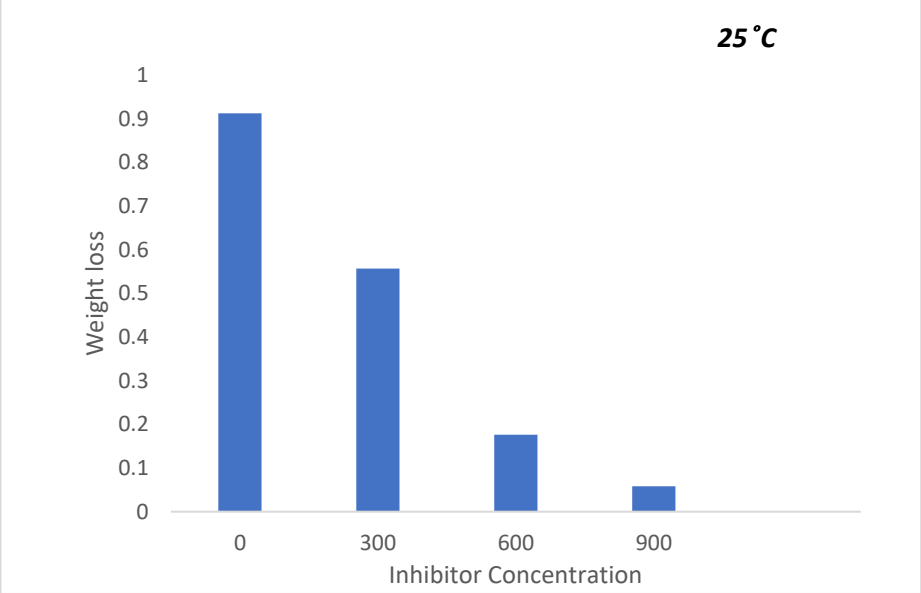
$$IE(100\%) = \frac{C_R^o - C_R^i}{C_R^o} \times 100$$

$$\theta = \frac{C_R^o - C_R^i}{C_R^o}$$

Table 1:- The information on iron's weight loss, corrosion rates, and effectiveness of inhibition in 0.5 M H_2SO_4 without and with different ppm of jamun extract-

Temperature (°C)	Metal	Inhibitor concentration(g)	Corrosion Rate (mmpy)	Efficiency (%)
25	Iron	0	35.01	0
		300	21.38	38.9
		600	6.75	80.7
		900	2.23	93.6
35	Iron	0	37.36	0
		300	23.61	36.8
		600	7.103	80.98
		900	4.49	87.9
45	Iron	0	38.9	0
		300	26.34	32.28
		600	7.39	81.25
		900	5.69	85.9

At different temperatures, the effect of inhibitor in the Weight loss shown in fig. 1,



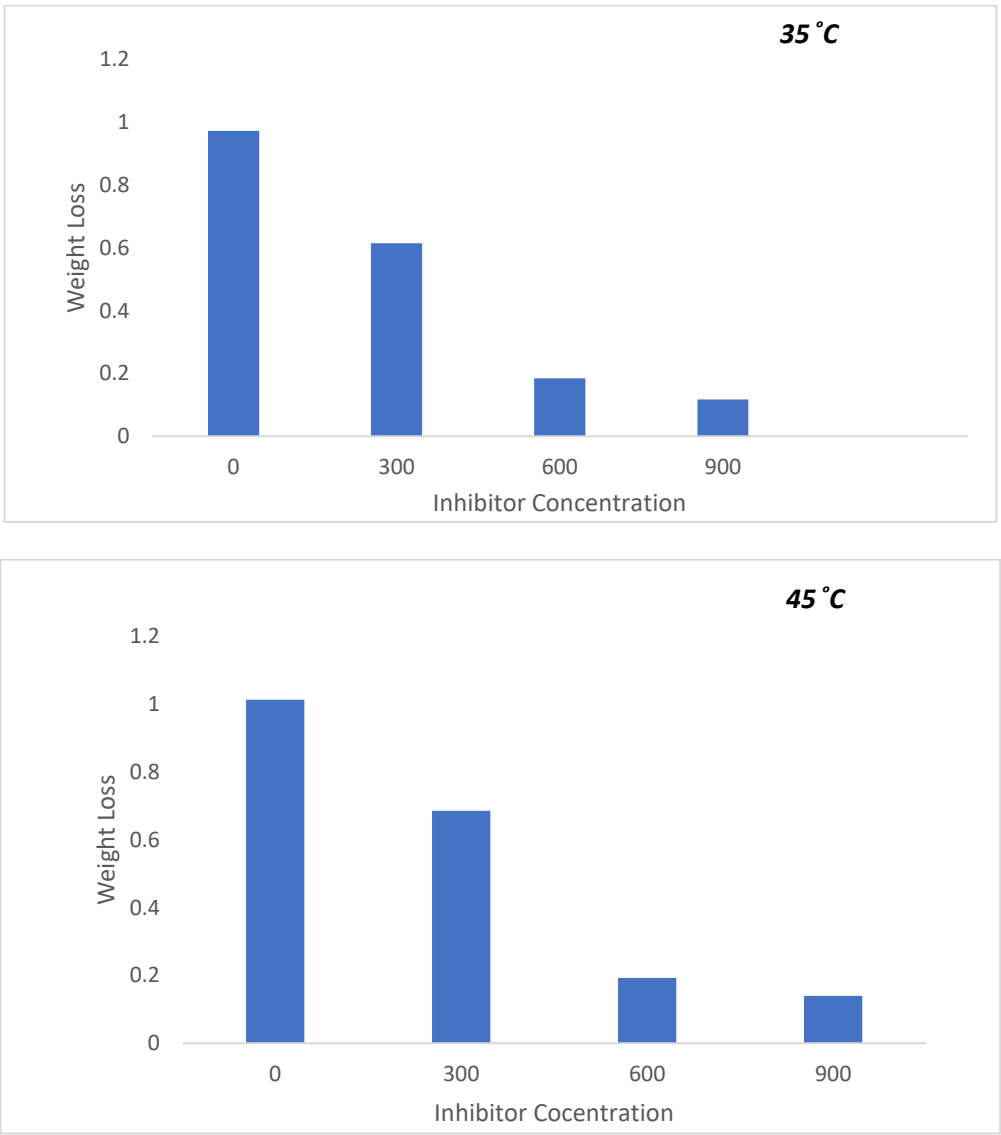
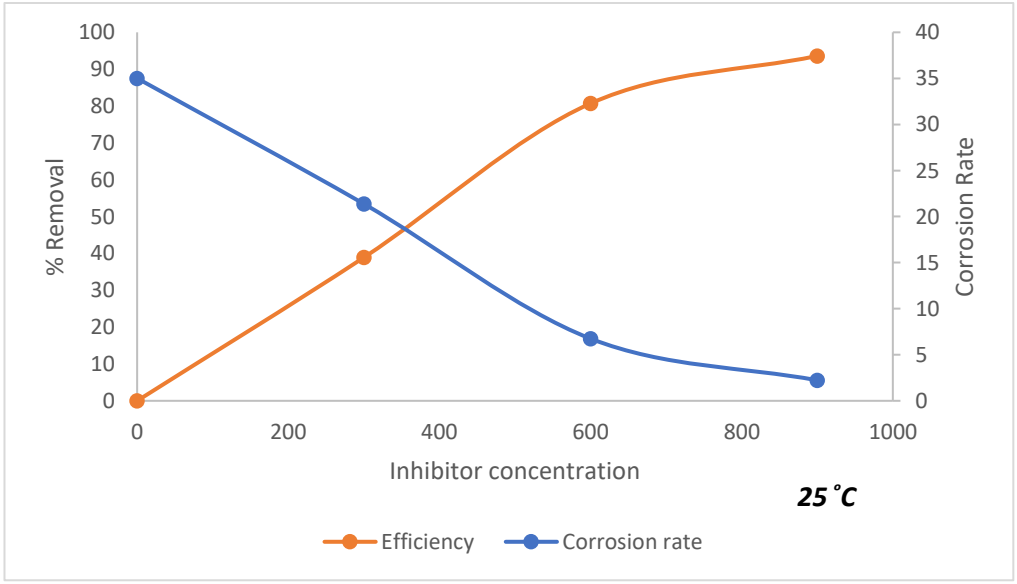
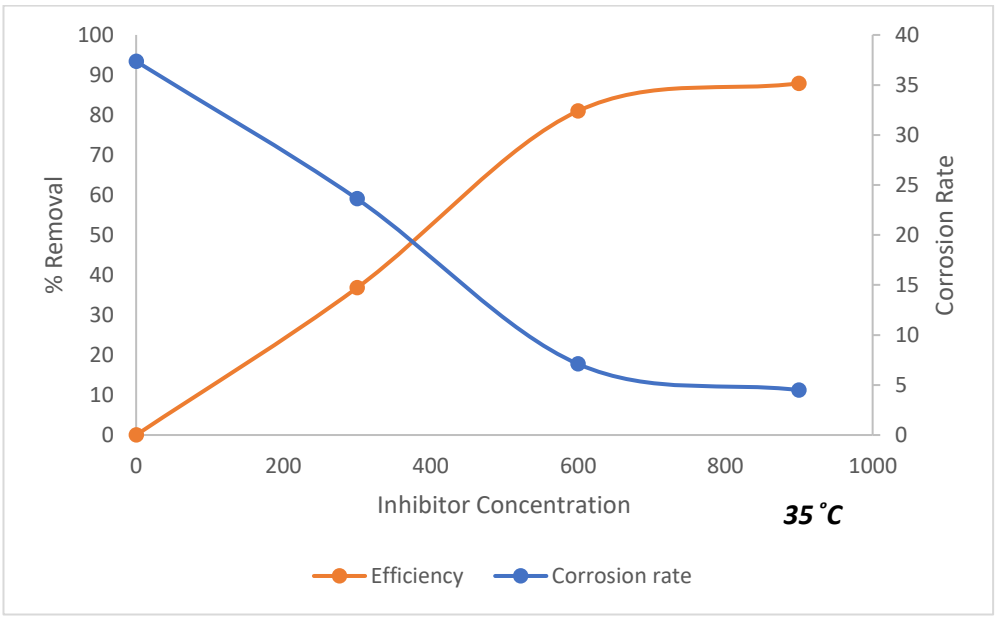


Fig 1. The Inhibitor (0, 300, 600, 900 ppm) against various weight losses of Jamun extract 0.5 M H_2SO_4 at various environmental temperatures of 25º, 35º and 45º C for 24 hours.





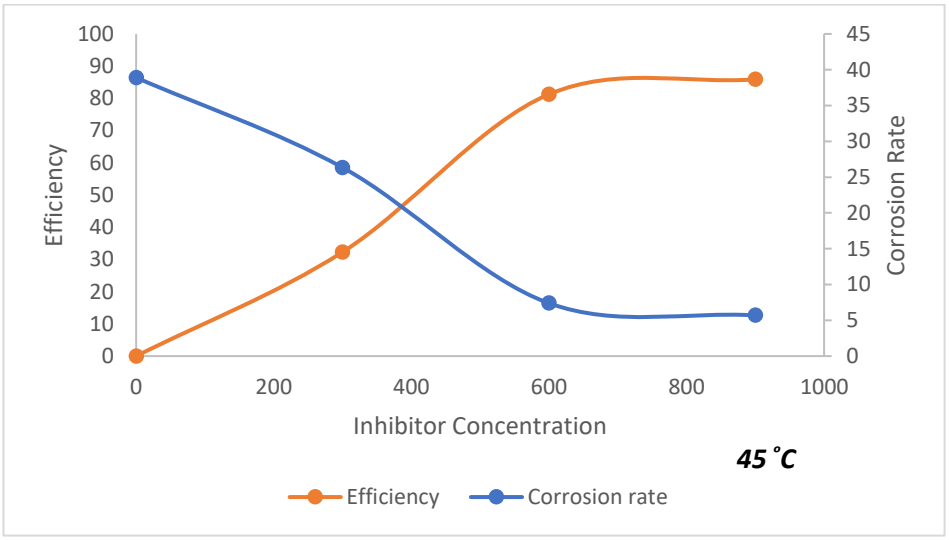


Fig 2. Iron specimens submerged in 0.5 M H_2SO_4 at 25, 35, and 45 °C at various ppm were tested for corrosion rate and inhibitor effectiveness.

FTIR Analysis:

the FTIR spectrum of Iron is shown below, Jamun powder and the Jamun extract after the immersed in the inhibitor solution.

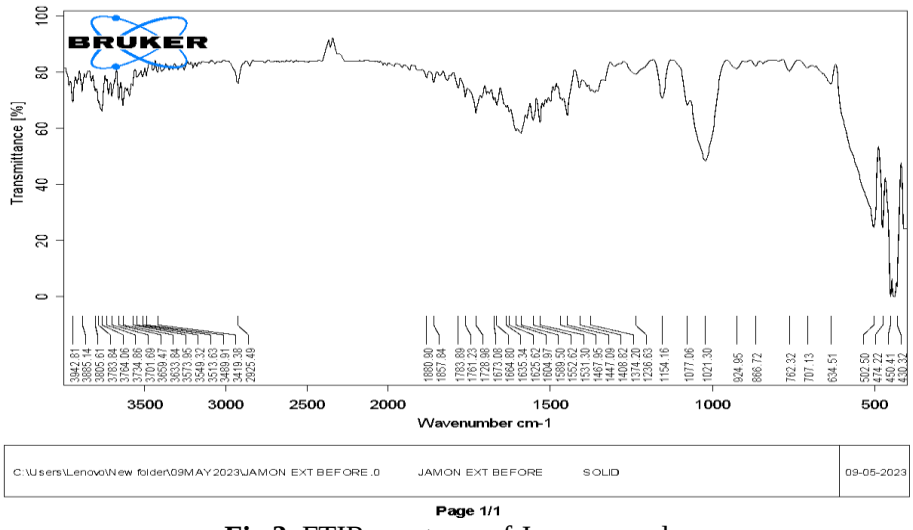


Fig 3. FTIR spectrum of Jamun powder

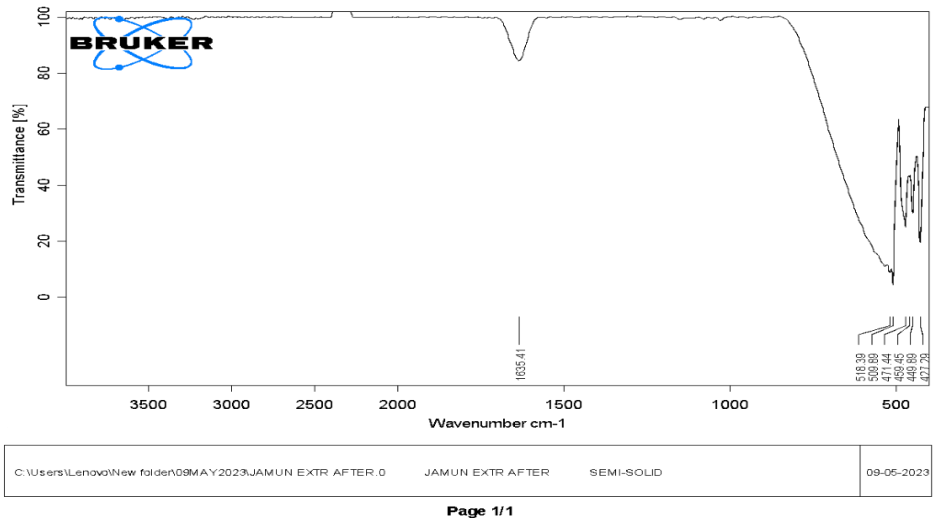


Fig 4. FTIR of Jamun Extract and Iron after immersion for 24 hours

UV Analysis

When comparing the Jamun extract before and after immersion (300, 600, 900 ppm) with Iron, the UV spectrum depicted in Figs. 5 and 6 was collected before and after the corrosion test, and the spectra varied in the location of the adsorption bands.

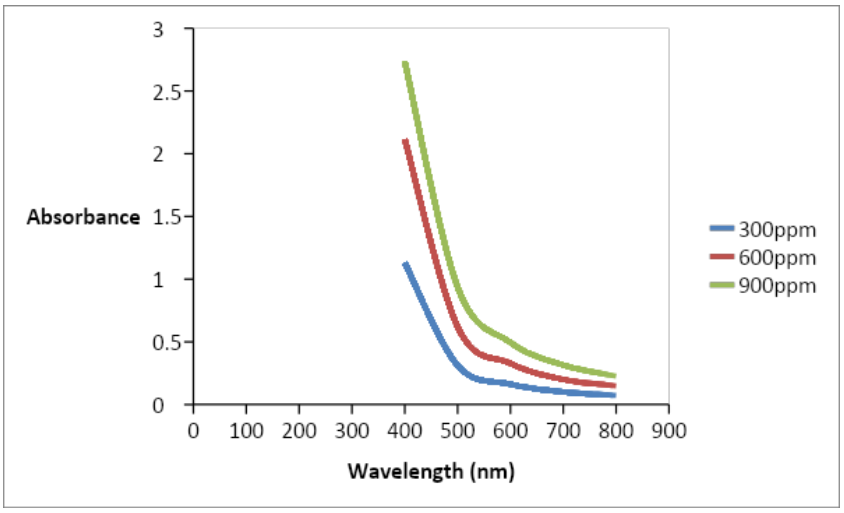


Fig 5. UV data for Jamun extract.

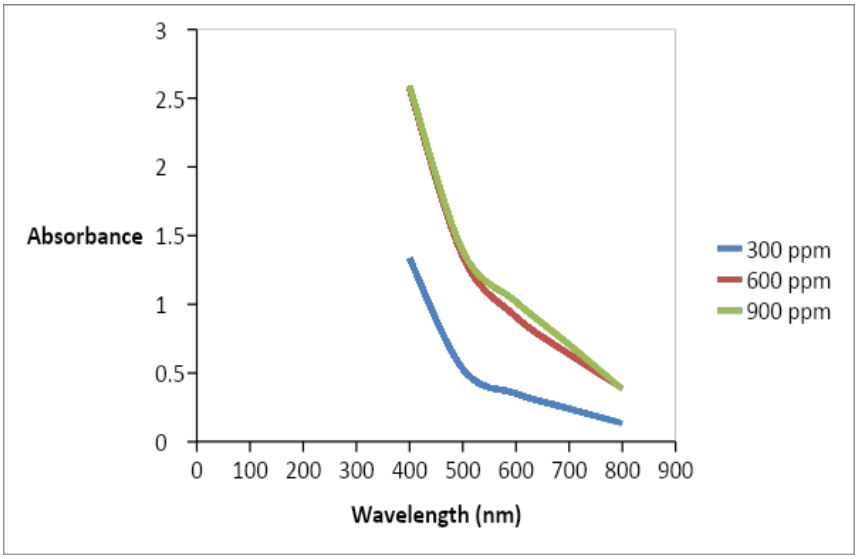


Fig 6. UV data of Iron after immersion in inhibitor solution

SEM Analysis

Iron specimens' surfaces were submerged in 0.5 M H_2SO_4 solutions with and without varying ppm (0, 300, 600, 900), and afterwards, the surfaces of the iron showed several signs of corrosion attack.

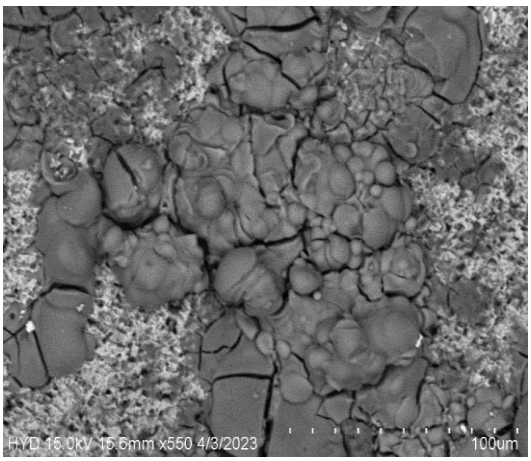


Fig 7. SEM Image of Iron without inhibitor

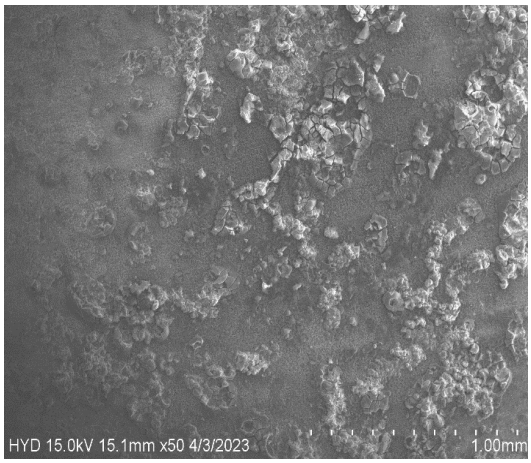


Fig 8. SEM Image of Iron with inhibitor

Adsorption isotherm:

The phenomenon of adsorption plays an important role during the action of corrosion inhibitors, It was discovered that the Langmuir adsorption isotherm, whose equation was used, provided the best fit.[35]:

$$\frac{\text{Cinh}}{\theta} = \frac{1}{\text{Kads}} + \text{Cinh} \qquad (5)$$

Kads is Adsorption equilibrium constant
Cinh is the inhibitor concentration

This isotherm considers that the adsorbed atoms are only present at one location and that no interactions between the adsorbed species exist. When the inhibitor concentration and Cinh/ were plotted, Kads was obtained.

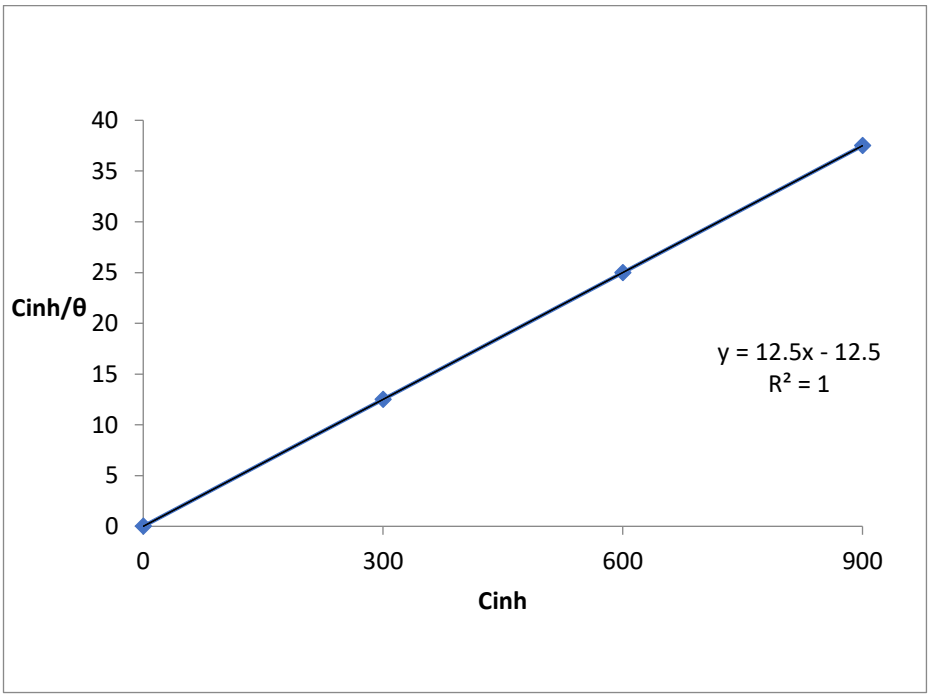


Fig 9. Langmuir plots for Jamun Extract at 298 K

Thermodynamic studies:

The value is based on the standard adsorption free energy (ΔGads)[35]:

$$\Delta G \text{ ads} = -RT\ln(55.5*\text{Kads}) \qquad (6)$$

ΔG ads = Gibbs free energy of adsorption

The interaction between adsorption molecules and metal surfaces is what gives the ΔGads their distinctive characteristics. The adsorption isotherm values for ΔGads are negative.

Kads= 0.08 is obtained from Fig. 9 and Gads= -3693.44 (kJ/mol) is obtained from equation 6 at 298 K.

Activation energy:

The Activation energy (Ea), which was determined using the weight loss measurement at 600 ppm, was calculated using the following equation.

$$\log CR = \frac{-Ea}{2.303RT} + \log P \qquad (7)$$

The slope of the line, as shown in Figure 10, was used to determine Ea as you plotted 1000/T vs. log CR. Activation energy, Ea = 0.373 kJ/mol.

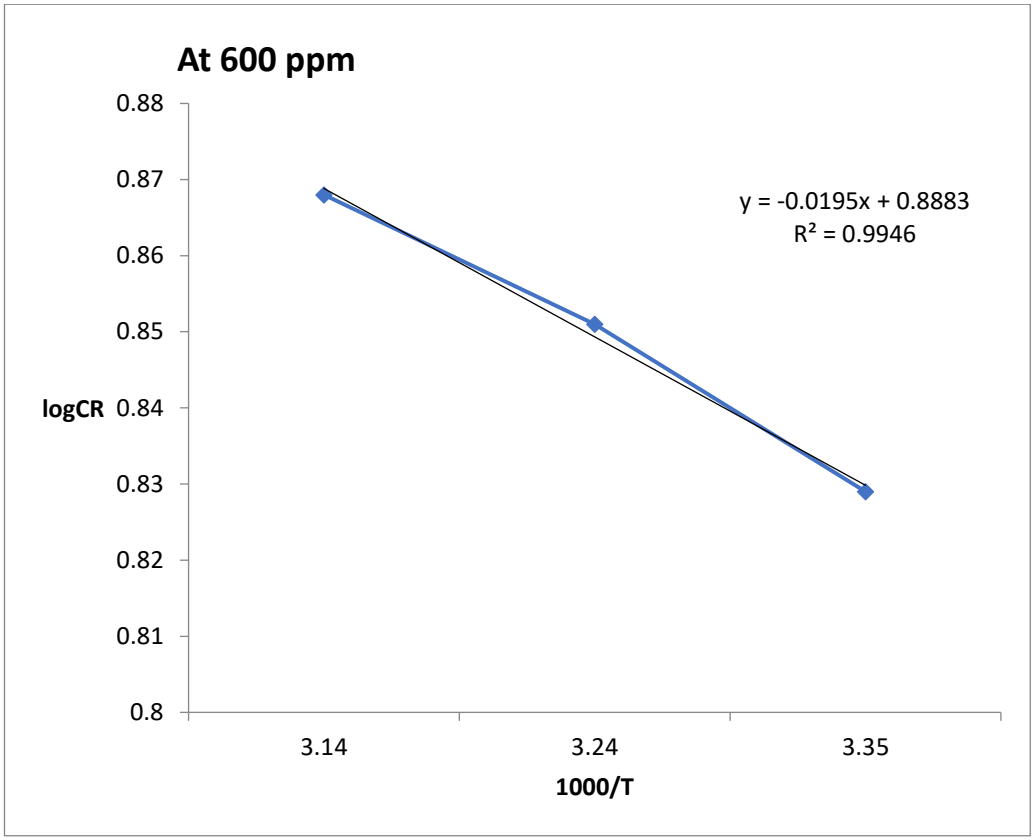


Fig 10. Arrhenius plot for Jamun Extract

CONCLUSION

After being synthesised into a green corrosion inhibitor for iron, the jamun extract was used to minimise the corrosion rate (CR) for iron surfaces in H_2SO_4 solution. Here is a summary of the research:

i. The Jamun Extract solution exhibited a maximum inhibitor efficiency of 93.6% at 900 ppm, with the inhibition efficiency (IE) rising as the level of inhibition increased in each case.
ii. In every case, an increase in the inhibitor led to a drop in the corrosion rate (CR).
iii. SEM research supports the development of protective film inhibitors on iron surfaces.
iv. The corrosion rate (C_R) was increasing with an increase in all temperatures and a decrease in each temperature.
v. Through FTIR investigation, UV visible the presence of many active components in the Jamun Extract was illustrated.

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