

Corrosion Inhibition on Mild Steel in Sulphuric Acid Medium Using Natural Product as Inhibitor

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Received 1 October 2014 / Accepted 17 October 2014

Abstract: The efficiency of *L. Acidissima* inhibitor on the corrosion of mild steel in acidic medium of different concentration of sulphuric acid has been investigated using weight loss measurements and FT-IR spectroscopic techniques. From the analysis it reveals that the inhibitor perform well in prevention of mild steel in 1 M H₂SO₄ and 2 M H₂SO₄ acid medium solution at room temperature in two hours. When comparing the efficiency, the inhibitor shows high efficiency in 1 M H₂SO₄ than 2 M H₂SO₄. Further the inhibition efficiency also been confirmed by surface morphological studies.

Keywords: Mild steel plate, Natural inhibitors, Eco friendly, Weight loss method, Surface Analysis

Introduction

In industrial applications mild steel were widely used which is intensified by various researchers in corrosion resistance in various aggressive environments¹⁻³. Several researchers devoted their attention to develop more effective and non-toxic inhibitors to reduce the acid attack and protection aspects⁴⁻⁹ were the problems arise from many industries. Amongst the various methods available, the use of inhibitors is one of the most practical methods for protection against corrosion especially in acidic media¹⁰⁻¹⁵. Natural products like lignin and tannin¹⁶, cinchona alkaloids¹⁷ and pomegranate alkaloids¹⁸ have been evaluated as very effective acid corrosion inhibitors in standard as well as in stringent conditions. Inhibition of corrosion was studied with the extracts of *Antrographis paniculata*¹⁹, *Adathoda Vasica* and *Piper Nigrum*.L²⁰ and with *Allamanda Balanchetti*²¹. The natural inhibitors studied have been found to be highly ecofriendly and possess no threat to the environment. In the present work, a systematic study has been undertaken to understand the corrosion behaviour of mild steel and the inhibitive action of *L. Acidissima* extract on

1 M H₂SO₄ and 2 M H₂SO₄ environment. It was found that the absorbed inhibitor on the mild steel surface accounts for protecting the metal from the corrosive medium and modifying the electrode reactions which is in favour of corrosion protection of the metal.

Experimental

The mild steel material of composition C=0.012%; Si=0.010%; Mn=0.19%5; S=0.014%; P=0.009%; Ni=0.014%; Mo=0.013%; Cr=0.040% and Fe=99.693% were cut into pieces of 5 × 1 cm strips for this study. They were polished according to the ASTM procedure²² using emery sheet of different grids, a hole at one end and numbered were punched over the surface of mild steel plate. The metal was polished with different grades of SiC abrasive papers (from grits 120 to 1200) and it is degreased using acetone.

Preparation of solutions

Preparation of extracts

The fruit of *L. acidissima* were cut into small pieces, shade dried and powdered. An aqueous extract of *L. acidissima* were prepared with soxhlet apparatus. From this various milli molar concentration of inhibitor solutions has been prepared. All the solutions were prepared using NICE brand AR grade chemicals in double distilled water and bubbling purified by nitrogen gas for 30 minutes to carry out de-aeration of the electrolytes. 1 M H₂SO₄ and 2 M H₂SO₄ solution was prepared by double distilled water.

Weight loss measurement

Mild steel specimens were immersed in 1 M H₂SO₄ and 2 M H₂SO₄ for two hours at room temperature (28±2 °C) at various concentration of inhibitor solution. After the duration of two hours the test specimens were removed rinsed in distilled water which is doubly purified and with acetone solution. The weight loss of the specimen were determined and recorded. From this, the inhibitor efficiency (IE %) was calculated using the following formula,

$$IE\% = \frac{W_o - W_i}{W_o} \times 100 \quad (1)$$

Where, W_O and W_i (in g) are the values of the weight loss observed of mild steel in the absence and presence of inhibitor respectively.

Scanning electron microscope (SEM analysis)

Using Scanning Electron Microscope (SEM- HITACHI S3000H, Japan) the surface of the metal was examined which is immersed into blank and inhibitor solution for two hours.

FT-IR studies

After the weight loss measurement the corroded parts were scrapped and the product was used for FT-IR studies. Using this spectral study the nature of adsorption of the inhibitor molecule over the metal surface was analyzed using FT-IR spectrophotometer (Perkin Elmer-1400).

Results and Discussion

Weight loss method

The comparison graph of corrosion behaviour and inhibitor efficiency of mild steel in 1 M H₂SO₄ and 2 M H₂SO₄ with *L. acidissima* was shown in Figure 1(a). Inhibition Efficiency

of *L. acidissima* was given in Figure 1 (b) which was studied by weight loss method at 2 h at room temperatures. From the graph, it was experimentally verified that the weight loss of mild steel in the acid decreases with increasing concentration of additives and the values were tabulated in Table 1 from which it clearly states that the corrosion rate has decreased with increasing concentration of inhibitor and inhibition efficiency increased with increasing the concentration of the inhibitor⁹. The inhibition efficiency in 1 M H₂SO₄ 54.89% and in 2 M H₂SO₄ the efficiency was 50.36% respectively at optimum concentration of the inhibitor solution for two hours at room temperature.

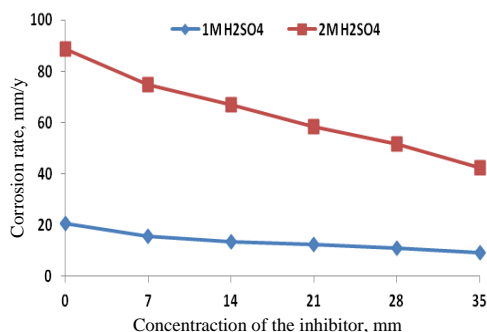


Figure 1(a). Comparison study of corrosion behaviour on 1 M H₂SO₄ and 2 M H₂SO₄ in *L. acidissima*

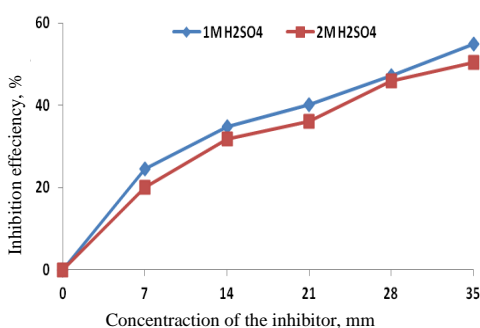


Figure 1(b). Comparison study of Inhibitor Efficiency on 1 M H₂SO₄ and 2 M H₂SO₄ in *L. acidissima*

Table 1. Corrosion parameters in absence and presence of *L. acidissima* 1 M H₂SO₄ and 2 M H₂SO₄

Inhibitor	Conc. of inhibitor mM	Corrosion Rate, mm/y	Inhibitor Efficiency, %	Corrosion Rate, mm/y	Inhibitor Efficiency, %
		1M H ₂ SO ₄		2M H ₂ SO ₄	
<i>L. acidissima</i>	Blank	20.5068	---	88.8259	---
	7.00	15.4916	24.45	74.6717	20.09
	14.01	13.3740	34.78	67.0931	31.71
	21.02	12.2595	40.21	58.5114	36.07
	28.03	10.8106	47.28	51.7129	46.00
	35.04	9.2503	54.89	42.4625	50.36

From the result obtained it was also concluded that the inhibitor was very efficient for preventing mild steel corrosion in 1 M H₂SO₄ and 2 M H₂SO₄. While comparing the result the inhibitor efficiency of 1 M H₂SO₄ is higher than 2 M H₂SO₄. Figure 2(a) revealed the comparison of corrosion rate (CR) with the inhibitor (in %) in 1 M H₂SO₄ and 2 M H₂SO₄ solution at 2 h at room temperature. Comparison of inhibition efficiency (IE) with concentration of *L. acidissima* (in %) in 1 M H₂SO₄ solution for two hours at room temperature is shown in Figure 2(b).

FT-IR spectral studies

This study is very useful in predicting the type of adsorption as well as bonding formation takes place at optimum concentration between the metal surface and the inhibitor used. Figure 2(a) represents the IR spectrum peaks of the inhibitor. In this spectrum the peak appeared at 3367cm⁻¹ corresponds to amide N-H stretching, 1510 cm⁻¹ corresponds to C=O

group, 1417 cm^{-1} corresponds to C-C stretching and from 1230 cm^{-1} to 1000 cm^{-1} the wavenumber indicates the presence of C-O bonding nature. Figure 2 (b and c) is similar to Figure 2 (a) which indicates the corrosion products contains *L. acidissima* in 1 M H_2SO_4 and 2 M H_2SO_4 . Therefore from the spectral data it is concluded that physisorption takes place between metal surface and the inhibitor molecule.

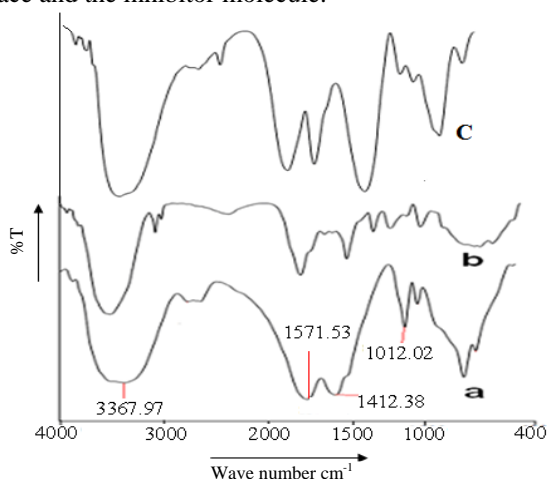


Figure 2. IR spectrum of the corrosion product showing adsorption in the presence of aqueous extract of *L. acidissima*

SEM analysis

The mild steel material which is cut into pieces were polished and immersed in the test solution for two hours acid solution. The test sample was prepared using double distilled water. The specimens were dipped into 1 M H_2SO_4 and 2 M H_2SO_4 which contains the inhibitor *L. acidissima* at optimum concentration and then the specimens were removed from the beaker, dried and kept in desiccators and it was observed under Scanning Electron Microscope (SEM) for surface morphological studies. The micrograph is shown in the Figure 3-6 show that the polished specimen was immersed in the blank solution of 1 M H_2SO_4 and 2 M H_2SO_4 and in the acids containing inhibitor *L. acidissima* which associated with polishing scratches. This result improves the surface coverage of the metal so that there is a decrease in the contact between metal and the aggressive medium.

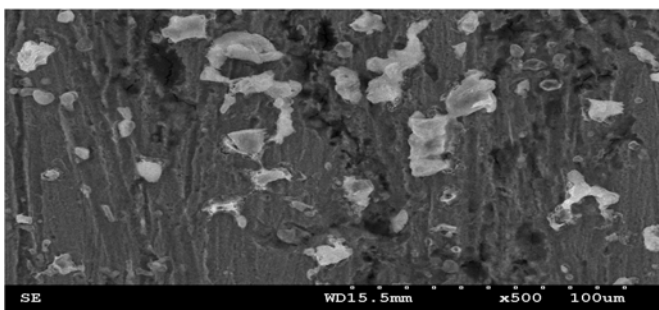


Figure 3. SEM images obtained for the mild steel surfaces immersed for 2 h in 1 M H_2SO_4 (blank acid solution)

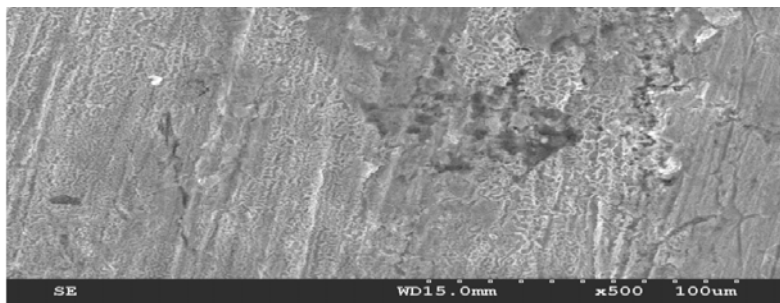


Figure 4. SEM images obtained for the mild steel surfaces immersed for 2 h in 1 M H₂SO₄ with 35.04 mM inhibitor solution

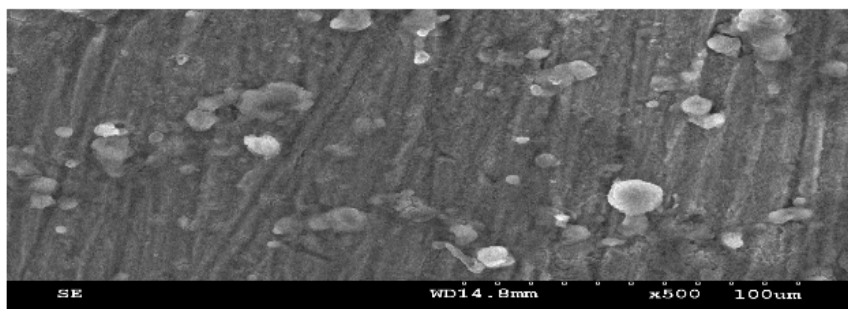


Figure 5. SEM images obtained for the mild steel surfaces immersed for 2 h in 2 M H₂SO₄ (blank acid solution)

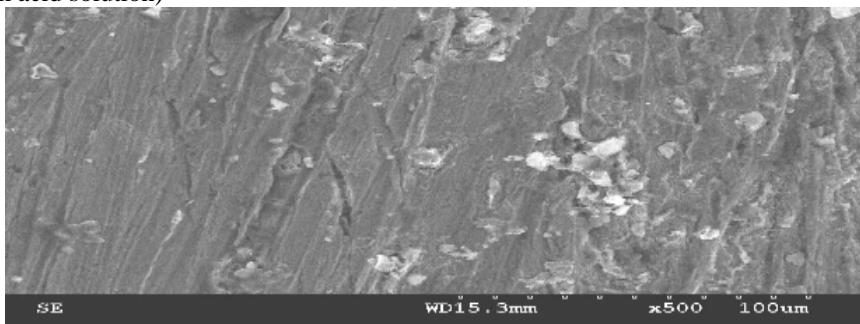


Figure 6. SEM images obtained for the mild steel surfaces immersed for 2 h in 2 M H₂SO₄ with 35.04 mM inhibitor solution.

Conclusion

From this above investigation it was concluded that the

1. *L. acidissima* shows better inhibition efficiency when dipped in 1 M H₂SO₄ and 2 M H₂SO₄. On comparing 1 M H₂SO₄ shows better results than 2 M H₂SO₄.
2. The inhibition efficiency of *L. acidissima* in 1 M H₂SO₄ was found to be 54.89% whereas in 2 M H₂SO₄ it shows 50.36% at optimum concentration.
3. FT-IR analysis confirm that the inhibitor efficiency of the inhibitor in mild steel through electrostatic attraction of inhibitor molecule and the metal surface.
4. The effective protection of mild steel, through the less damaged and minimum crack found in the inhibited surface confirmed from surface morphological studies.

Acknowledgement

I very much thankful to AMET University for providing the facilities for smooth conduction of this research work.

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