Volume: 4 Issue: 10 Pages: 94-100

Evaluation of Metal Corrosion Inhibition by Artocarpus Altilis Extract

*1 Suhasini S, 2Vaikundamani M and 3Dr. K Anbarasi

[1,2] M.Sc, Department of Chemistry, Nirmala College for Women, Coimbatore, Tamil Nadu, India.

[*3] Associate Professor, Department of Chemistry, Nirmala College for Women, Coimbatore, Tamil Nadu, India.

Article Info.
E-ISSN: 2583-6528
Impact Factor (SJIF): 6.876
Peer Reviewed Journal
Available online:
www.alladvancejournal.com

Received: 16/Sep/2025
Accepted: 18/Oct/2025

***Corresponding Author**
Dr. K Anbarasi
Associate Professor, Department of Chemistry, Nirmala College for Women, Coimbatore, Tamil Nadu, India.

Abstract

Green corrosion inhibitors derived from plants have gained importance as they are inexpensive, eco-friendly, and rich in naturally occurring phytochemicals. In the present work, the corrosion inhibition efficiency of *Artocarpus altilis* leaf extract (AAL) on mild steel (MS) in 1N H_2SO_4 medium was investigated. The study employed weight loss method to evaluate inhibition efficiency, Fourier Transform Infrared (FTIR) spectroscopy to identify functional groups responsible for adsorption, and Scanning Electron Microscopy (SEM) to examine the surface morphology of MS specimens. Weight loss measurements demonstrated that AAL extract significantly reduces corrosion rate, showing higher efficiency with increasing concentration. FTIR results indicated the presence of functional groups such as hydroxyl and carbonyl, which may interact with the metal surface, leading to the formation of a protective layer. SEM analysis further confirmed surface smoothening and reduction of corrosion damage in the presence of the extract. Thus, *Artocarpus altilis* leaf extract can be considered as an effective, renewable, and environmentally sustainable green corrosion inhibitor for mild steel in acidic media.

Keywords: *Artocarpous altilis leaf* (AAL), mild steel, phytochemical screening, SEM, and FTIR, weight loss method

1. Introduction

Corrosion is a natural, electrochemical process that gradually degrades materials, most often metals, through a reaction with their environment. It is a widespread and costly issue that affects various industries, from infrastructure and automotive to electronics. The most common form of corrosion is the rusting of iron, which occurs when iron reacts with oxygen and moisture to form iron oxides. [1]

The process of corrosion is essentially a series of electrochemical reactions. In the case of a metal, a section of the surface acts as an anode, where the metal atoms lose electrons (oxidation) and become positively charged ions. These free electrons then travel to another section of the surface, which acts as a cathode, where they are consumed by a reduction reaction, often involving an oxidant like oxygen. The overall effect is the gradual deterioration of the metal's structure and properties. [2] Several natural products like Cucurbita maxima [3], Argemone Mexicana [4], Justicia gendarussa [5], Thymus vulgaris [6], Ferula hermonis [7], adhatoda vasica [8], Verbena officinalis [9], Delonix Regia [10], cardiospermum halicacabum [11] are seen to be an effective corrosion inhibitors in acid medium.

Due to the significant economic and safety implications of corrosion, various methods have been developed to prevent or mitigate it. These include applying protective coatings, using cathodic protection, and employing corrosion inhibitors. Recently, there has been a growing interest in using natural, environmentally friendly compounds as corrosion inhibitors, which brings us to the topic of Artocarpus altilis. [12]

The leaves of Artocarpus altilis are particularly rich in bioactive compounds, such as flavonoids, tannins, and phenolic compounds. These compounds have been studied for their antioxidant, anti-inflammatory, and antimicrobial properties. It is these same phytochemicals that make Artocarpus altilis leaf extract a potential green corrosion inhibitor. The presence of these compounds, particularly flavonoids and tannins, allows them to form a protective layer on a metal surface, which helps to slow down or prevent the electrochemical reactions that lead to corrosion. [14]

2. Experimental

Materials and Methods

2.1 Materials

The sheet of mild steel (MS) used for this study has 2mm in thickness and was mechanically press-cut into 5cm × 1 cm coupons. The 1N Sulphuric acid Solution, prepared from AR grade Sulphuric acid was employed as the corrodent for the study. The extract was prepared by refluxing 50g of powdered leaves of Artocarpous altilis (AAL) in 1000 ml of 1N Sulphuric acid for 3 hour kept for heating. Then it was filtered and this was taken as a stock solution. From the respective stock solution, inhibitor test solutions were prepared in the concentration range from 0.01% v/v to 3%v)v.

Fig 1: Mild steel sample, fresh leaves of AAL and powdered sample

2.1 Methods

2.1.1 Phyto Chemical Analysis

Qualitative Phytochemical analysis of the crude extract of the Artocarpus altilis leaves was determined according to the standard procedure [15] identity the constituents as described. Dragendorff teat for alkaloids, Foam test for saponins, test for terpenoids, test for tannins, test for carbohydrate, Biuret test for Protein, test for flavonoids and glycosides were performed to identify the constituents present in the extract of the leaves of the plant.

2.1.2 Weight Loss Method

The weight loss method was used to optimize the concentration of the inhibitors. Initially the mild steel specimen was weighed and noted. The mild steel were immersed in 100ml of inhibited and uninhibited solutions for various Time-intervals at room temperature. After the immersion the specimens were withdrawn, rinsed with distilled water, dried in the desiccators and weighed accurately. Weight loss measurements were also performed at various immersion time like 1 hour, 3 hours, 5 hours, 7 hours and 24 hours for the different concentration of the AAL extract at room temperature. From the table, initial and final weight was calculated and the efficiency of inhibitor at various immersion time was calculated. The corrosion rate (mpy) and the inhibition efficiency were calculated.
The weight loss measurements carried out at various time intervals. The weight of the specimens before and after immersion was determined using a digital balance.
The corrosion rate (CR) was calculated from the following equation.

$$CR = (534 \times W) / D\,A\,T$$

W-Weight loss of the mild steel
D-Density of the mild steel (Kg/m3)
T-Time of immersion
A-Area of the specimen exposed to the corrosive solution (m2)

The percentage inhibition efficiency (IE%) was calculated from the following equation.

$$IE\% = [CR\ (blank) - CRi/CR\ (blank)] \times 100\%$$

CR (blank)–Corrosion rate of the blank solution (mpy)
Cri-Corrosion rate of the inhibitor (mpy)

The weight loss study revealed that both immersion time and temperature the corrosion rate of the metal and inhibition efficiency of the plant extract increased with increasing inhibitor concentration from 0.01% to 3% v/v.

2.1.3 FT-IR Analysis

FT-IR analysis has been made to obtain some understanding into the possible interactions between the adsorbed molecule and the mild steel surface in the acidic environment. The FT-IR provides us with the basic idea about the functional groups present in the inhibitor molecule. The FT-IR spectrum of the seed extract of Artocarpous altilis.
The crude extract mild steel in 1N sulphuric acid blank AAL,1% AAL and 3% AAL extract subjected to FTIR analysis at Avinashilingam Institute of Home Science and Higher Education for Women (Bharati Ratna prof, CNR Rao research Centre), Coimbatore.

2.1.4 SEM-Edax Analysis

The analysis of morphological character of the mild steel was studied by the SEM analysis and determination of the elemental composition of the mild steel was studied by the EDAX analysis. The scanning electron microscopic micrograph of mild steel in the presence and absence of optimum concentration of AAL extract after an immersion time of 3 hours. After completion of the experiment the specimum were removed and dried.
Surface morphology of mild steel inhibition blank,1%,3% of AAL rested for SEM analysis at Avinashilingam Institute of Home Science and Higher Education Women (Bharati Ratna prof, CNR Rao research Centre), Coimbatore.

3. Results and Discussion

3.1 Phytochemical Screening

Table: 1 shows the presence Phyto chemicals like flavanoid, tannins, glycosides, phenol, coumarins and carbohydrate in the acid plant extract. Negative result observed in alkaloids, saponins, steroids, terpenoinds, quinones and protein. The preliminary screening of the Artocarpous altilis leaf extract showed that phyto chemicals are stable in aggressive environment.

Table 1: Phytochemical Analysis

Phytochemical Analysis	Observation
Tannin	+
Alkaloids	-
Saponins	-
Flavonoids	+
Steroids	-
Terpenoids	-
Phenol	+
Quinones	-
Carbohydrate	+
Coumarin	+

3.2 Weight Loss Method
Weight loss method of Artocarpous altilis in 1N sulfuric acid at different immersion period are shown in Table 2. From the weight loss method the corrosion rate is decreases with increasing concentration of the inhibitor efficiency at 1, 3, 5, 7, 24 hours. Corrosion rate of metal from 872 to 44 mpy at 1 hour immersion period, from 1236 to 15 mpy at 3 hour immersion period, from 1352 to 17 mpy at 5 hour immersion period, from 1289 to 12 mpy at 7 hour immersion period, from 1752 to 16 mpy at 24 hour immersion period. Inhibition efficiency from 0 to 95 at 1 hour immersion period, from 0 to 99 at 3 hour immersion period, from 0 to 99 at 5 hour immersion period, from 0 to 99 at 7 hour immersion period, from 0 to 99 at 24 hour immersion period.

Table 2: Weight loss method of AAL in 1N Sulfuric acid at different immersion periods.

Conc. Of Extract	1 hour		3 hour		5 hour		7 hour		24 hour	
	CR (mpy)	IE %	CR (mpy)	IE %	CR (mpy)	IE %	CR (mpy)	IE %	CR (mpy)	IE %
Blank	872	-	1236	-	1352	-	1289	-	1752	-
0.01	480	45	780	35	898	34	617	52	896	49
0.05	436	50	509	59	776	43	498	61	380	78
0.1	392	55	320	74	366	73	330	74	207	88
0.5	349	60	189	85	270	80	181	86	162	91
1	349	60	145	88	148	89	162	87	93	95
1.5	262	70	73	94	78	94	118	91	42	98
2	218	75	58	95	44	97	106	92	40	98
2.5	174	80	29	98	26	98	19	99	31	98
3	44	95	15	99	17	99	12	99	16	99

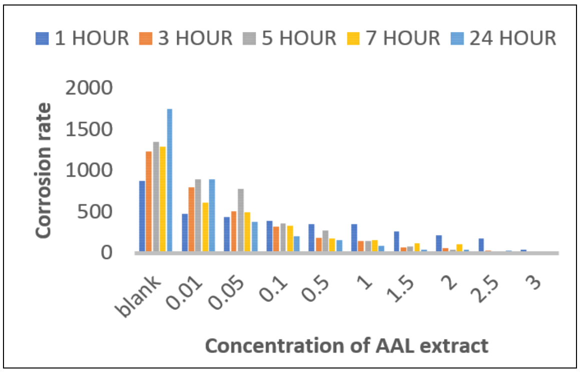


Fig 2: conc. of AAL extract vs Corrosion rate

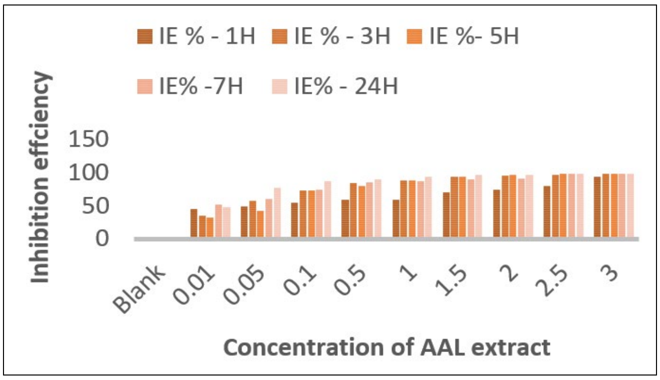


Fig 3: Inhibition effciency vs conc. Of extract

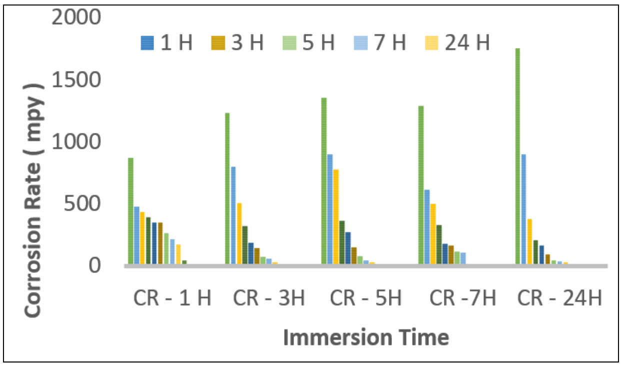


Fig 4: Corrosion rate vs. immersion time

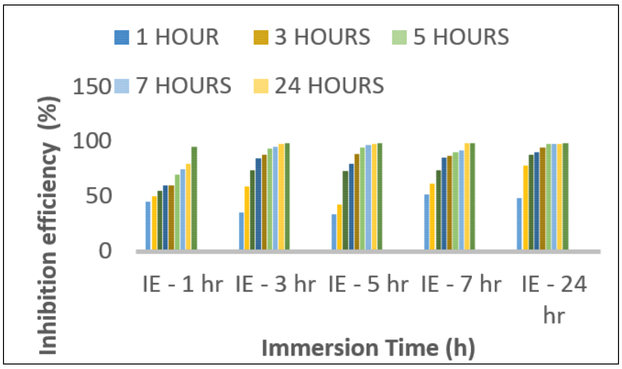


Fig 5: Inhibition efficency vs time

3.3 FT-IR Analysis
FT-IR analysis has been made to obtain some understanding into the possible interactions between the adsorbed molecule and the mild steel surface in the acidic environment. The FT-IR provides us with the basic idea about the functional groups present in the inhibitor molecule. The figure: 6 shows that FT-IR spectrum of the seed extract of Artocarpous altilis. The figure: 7 shows that FT-IR spectrum of mild steel at the blank. In that blank there is the absence of AAL molecules on the specimen. The AAL extract adsorbed on the surface of mild steel were studied to evaluate the main functional groups. The spectrum of inhibitor adsorbed on the mild steel surface shows almost all the characteristic peaks. The low intensity of the peaks may indicate the bond formation as well as a thin layer of inhibitor coating on the mild steel surface. IR spectra of the specimen mild steel with 1% HPS and 3% extract showed in the fig. 8 and 9 shows the presence of groups like OH, C-O, N-O, C-H and etc. This shows the anticorrosive properties of the mild steel by the AAL extract.

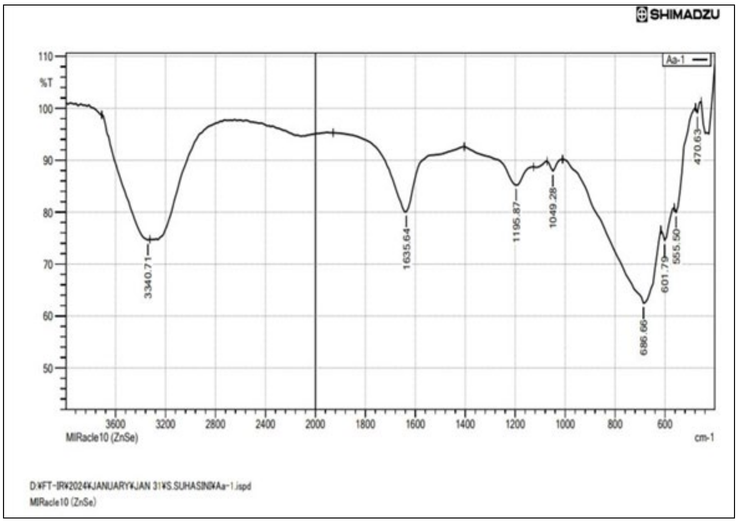


Fig 6: The IR spectrum of the AAL extract

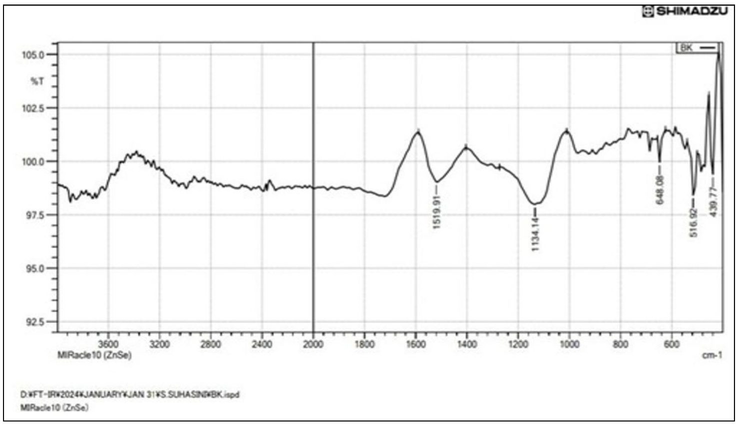


Fig 7: The IR spectrum of the mild steel (Blank)

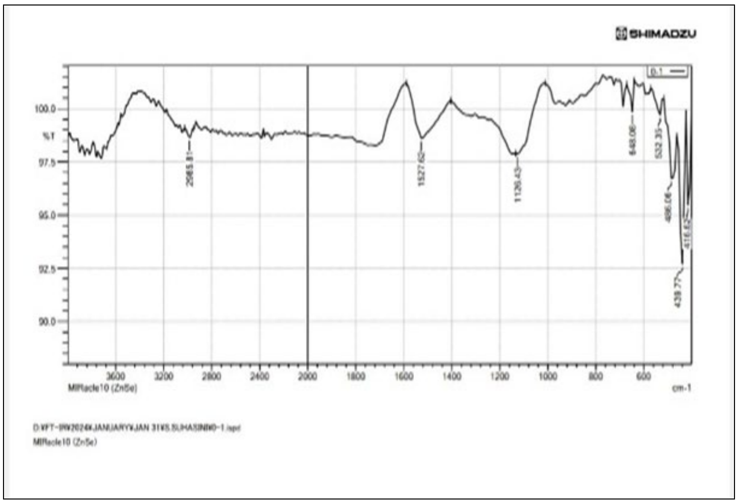


Fig 8: The IR spectrum of mild steel in 1% AAL

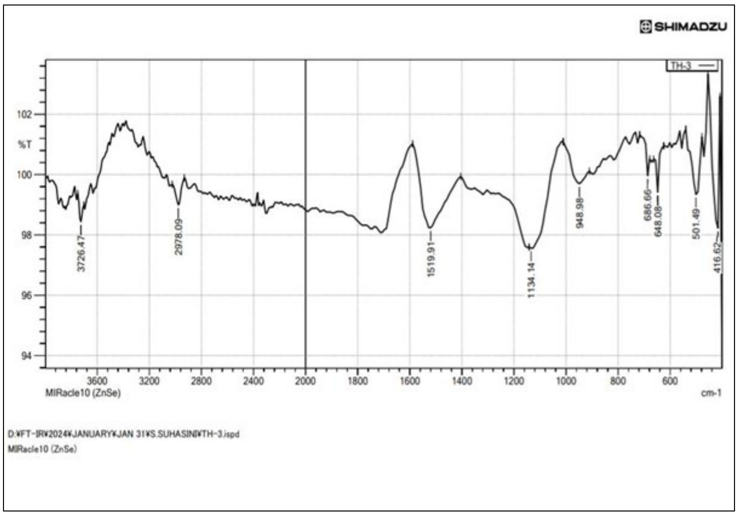


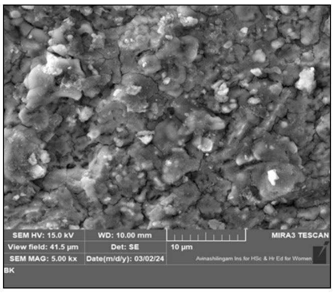
Fig 9: The IR spectrum of mild steel in 3% AAL

Table 3: FTIR peak value of mild steel in 1N Sulphuric acid AAL extract, Blank, 1% and 3% AAL

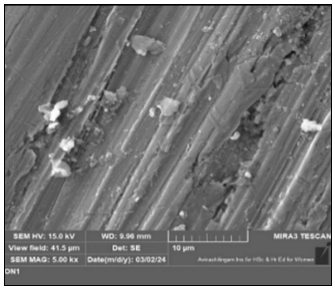
S. No.			FTIR Peak value cm^{-1}		
	AAL extract	MS in Blank	MS in 1% AAL	MS in 3% AAL	Possible Functional group
1	3340.71		3726.47		O-H stretching
3			2978.09	2985.81	C-H stretching
5	1635.64				C=C stretching
6			1519.91	1527.62	N-O stretching
7		1519.91			Fe(COOH)
9	1195.87			1126.43	C-O stretching
10		1134.14			¥ Fe(COOH)
11			1134.14		C-N stretching
14		648.08			Feo
15				648.08	C-X stretching
16		516.92			Fe2O3

3.4 SEM Analysis

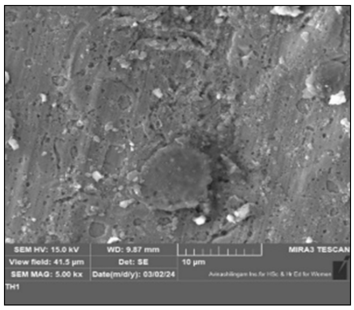
The analysis of morphological character of the mild steel was studied by the SEM analysis and determination of the elemental composition of the mild steel was studied. The scanning electron microscopic micrograph of mild steel in the presence and absence of optimum concentration of AAL extract after an immersion time of 3 hours. After completion of the experiment, the specimens were removed and dried with the drier. Three different samples were taken with different concentrations like blank, 1% and 3% with AAL extract. Surface analysis of the mild steel was made using scanning electron microscope with the different magnificent. It is clear that the surface of mild steel was strongly damaged in the acid solution without AAL extract. The image results a severe dissolution of the mild steel in exposure with acid solution without inhibitor. The visual performance of the mild steel surface exposed to acid solution was significantly changed in the presence of AAL extract. That the AAL extract reduced dissolution rate of mild steel and lower corrosion products were formed on the mild steel surface in the presence of inhibitor. The lowest surface damage were observed at the highest AAL extract. The SEM studies showed that the inhibited mild steel surface was found smoother than the uninhibited surface due to the formation of protective film on the inhibited mild steel surface.



(a)



(b)



(c)

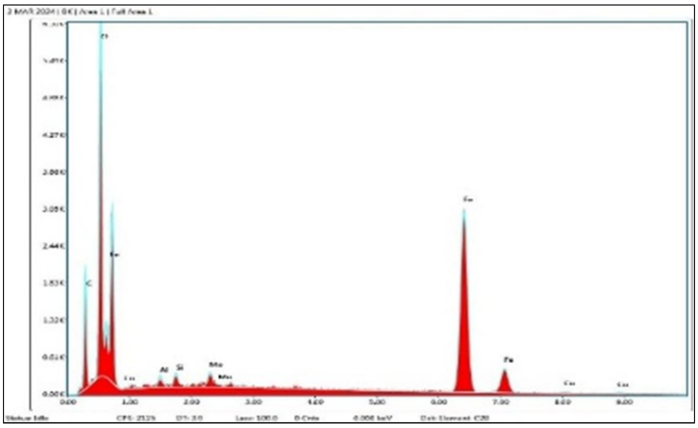
Fig 10: SEM images of mild steel in blank (10a), 1% AAL (10b), 3% AAL (10c) at 5.00 kx magnification

EDAX Analysis

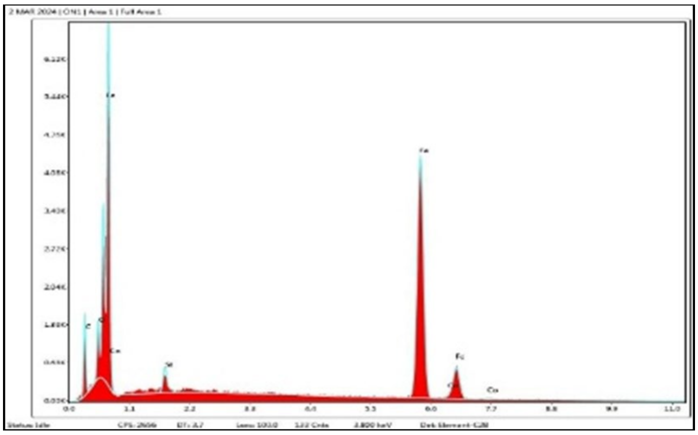
EDAX Analysis is used to determine the elemental composition of the mild steel in Presence and absence of AAL extract. The EDAX analysis of mild steel in the absence and presence of an optimum concentration of AAL extract. Depicted the EDAX analysis of mild steel in the absence of AAL extract. It was observed that the EDAX analysis of mild steel in the absence of AAL Blank shows signals for carbon (11.22%), oxygen (16.58%), iron (67.94%), Aluminum (0.66%), Silicon (0.69%), Molybdenum (1.75%), and Copper (1.16%) elements. The EDAX spectra of mild steel in the presence of 1% AAL extract shows the Characteristic signals for carbon (7.81%), oxygen (2.42%), iron (87.18%), Silicon (1.32%), Cobalt (1.27%). The EDAX spectra of mild steel in the presence of 3% AAL extract shows the Characteristics signals for Carbon (7.81%), Oxygen (2.42%) Silicon (1.32%), Iron (87.18%), Cobalt (1.27%).

Table 4: EDX analysis of AAL

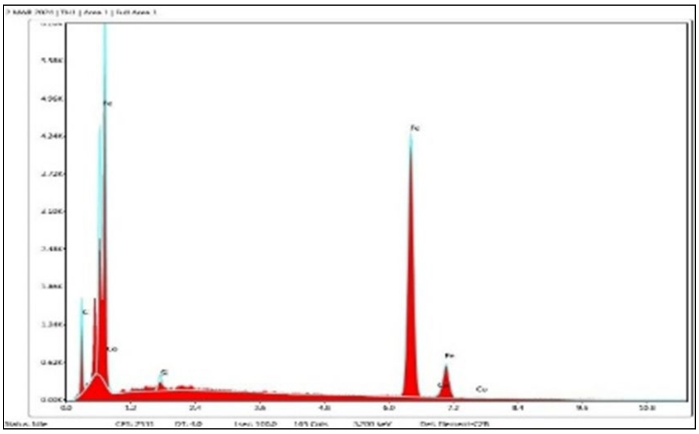
Elements	Blank	1% AAL	3% AAL
Carbon	11.22	7.81	8.66
Oxygen	16.58	2.42	0.52
Silicon	0.69	1.32	0.76
Iron	67.94	87.18	89.63



(a)



(b)



(c)

Fig 11: EDX analysis of mild steel in 1N sulfuric acid in blank (11a), 1% AAL (11b), 3% AAL (11ac)

Conclusion
- The mild steel corrosion inhibition of Artocarpus altilis leaf extract is investigated in a IN H_2SO_4 solution using Preliminary screening, weight loss method, FTIR. SEM & EDX analysis.
- Preliminary phyto chemical screening revealed that the presence of possible secondary metabolites such as Tannin, Flavonoids, Phenol, Carbohydrates and Coumarin. These phytochemicals are responsible for corrosion inhibition of metal surface in acidic environment.
- Weight loss method revealed that the corrosion rate of mild steel decreased and inhibition efficiency of plant extract increased when concentration of the inhibitor increased. Maximum inhibition efficiency of 95% obtained at 3% concentration of Artocarpus altilis at 1 hour and 99% of inhibition efficiency obtained at 3% of Artocarpus altilis at 24 hours.
- FTIR analysis showed that the presence of possible functional groups such as OH, C-C, C-O, C-X etc., adsorption of these functional groups retard the metal dissolution.
- The efficiency of absorption of plant extract on mild steel confirmed by SEM and EDX analysis.
- The above results proved that the tested inhibitor Artocarpus altils acted as good green inhibitor in corrosive environment.

References

1. Cinitha A, Umesha PK, Iyer NR. An overview of corrosion and experimental studies on corroded mild steel compression members. *KSCE Journal of Civil Engineering*. 2014; 18(6):1735-1744.
2. Kumpawat V, Bansal L, Garg U, Mathur SP, Tak RK. Corrosion inhibition of mild steel by alcoholic extract of Artocarpus heterophyllus in acidic media. *International Journal of Applied Chemistry*. 2010; 6(3):297-309.
3. Anbarasi K, Vasudha VG. Mild steel corrosion Inhibition by Cucurbitamaxima plant extract in hydrochloric acid solution. *J. Environ. Nanotechnol*. 2014; 3(1):16-22.
4. Ji G, Shukla SK, Dwivedi P, Sundaram S, Prakash R Inhibitive effect of Argemone mexicana plant extract on acid corrosion of mild steel. *Industrial & Engineering Chemistry Research*. 2011; 50(21):11954-11959.
5. Satapathy AK, Gunasekaran G, Sahoo SC, Amit K, Rodrigues PV. Corrosion inhibition by Justicia gendarussa plant extract in hydrochloric acid solution. Corrosion science. 2009; 51(12):2848-2856.
6. Ehsani A, Mahjani MG, Hosseini M, Safari R, Moshrefi R, Shiri HM. Evaluation of Thymus vulgaris plant extract as an eco-friendly corrosion inhibitor for stainless steel 304 in acidic solution by means of electrochemical impedance spectroscopy, electrochemical noise analysis and density functional theory. *Journal of colloid and interface science*. 2017; 490:444-451.
7. Fouda AS, Mohamed OA, Elabbasy HM. Ferula hermonis plant extract as safe corrosion inhibitor for zinc in hydrochloric acid solution. *Journal of Bio-and Tribo-Corrosion*. 2021; 7(4):135.
8. Singh MR. A green Approach: A corrosion inhibition of mild steel by adhatoda vasica plant extract in 0.5 MH2so4. Environments. 2013; 10:19.
9. Fouda AEAS, Molouk AF, Atia MF, El-Hossiany A, Almahdy MS. Verbena officinalis (VO) leaf extract as an anti-corrosion inhibitor for carbon steel in acidic environment. Scientific Reports. 2024; 14(1):16112.
10. Abiola OK, Oforka NC, Ebenso EE, Nwinuka NM. Eco-friendly corrosion inhibitors: the inhibitive action of Delonix Regia extract for the corrosion of aluminium in acidic media. Anti-Corrosion Methods and Materials. 2007; 54(4):219-224.
11. Suleiman IY, Kasim A, Ochu SR. Anti-corrosion properties of ethanol extract of cardiospermum halicacabum leaf on steel pipelines in acidic environment. *Journal of Bio-and Tribo-Corrosion*. 2019; 5(3):65.
12. Tewari BB. Phytochemical Analysis and Antimicrobial Screening of Artocarpus altilis: Guyana Flora Extracts. *Current Journal of Applied Science and Technology*. 2023; 42(45):33-45.
13. Sikarwar MS, Hui BJ, Subramaniam K, Valeisamy BD, Yean LK, Balaji K. A review on Artocarpus altilis (Parkinson) Fosberg (breadfruit). *Journal of Applied Pharmaceutical Science*. 2014; 4(8):091-097.
14. Lubis S, Sayuti M, Muhammad M, Mulyawan R, Islami N. Effect of jackfruit seed extract (artocarpus heterophyllus) concentration on corrosion inhibition of galvanized steel in seawater. Jurnal Polimesin. 2025; 23(1):101-105.
15. Banu KS, Cathrine L. General techniques involved in phytochemical analysis. *International journal of advanced research in chemical science*. 2015; 2(4):25-32.