



**ADSORPTION AND ELECTROCHEMICAL BEHAVIOR OF
"EUGENIA SINGAMPATTIANA BEDDOME" LEAVES ON MILD STEEL IN
NATURAL SEAWATER ENVIRONMENT**

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Abstract

Effect of Eugenia Singampattiana Beddome leaves extract on erosion of mild steel in Natural ocean water was researched by Mass loss and Electrochemical measures with various period of contact and temperature. The observed results indicate that the erosion inhibition effectiveness was increased with increase of inhibitor concentration but dropped gradationally with rise in temperature effect of "Eugenia Singampattiana Beddome" leaves extract on erosion of mild steel in Natural sea water was researched by mass loss and electrochemical measures with various period of contact and temperature. The observed results indicate that the erosion inhibition effectiveness was increased with increase of inhibitor concentration but dropped gradationally with rise in temperature. The highest possibility of inhibitory effectiveness was 95.24 %. For the erosion process, the thermodynamic parameters (E_a , ΔH_{ads} , ΔS_{ads}) were calculated, which suggests that the adsorption is exothermic, spontaneous, and Physisorption. The Langmuir adsorption isotherm is followed by the inhibitor. (The average coefficient of regression is 0.9917) Various spectroscopic research, FT-IR, EDX, and XRD techniques were used to examine the corrosion products created on the metal surface, and the film production was also validated by SEM picture. The maximum chance of inhibition effectiveness attained 95.24%. The thermodynamic parameters (viz; E_a , ΔH_{ads} , ΔS_{ads}) were estimated for erosion process, which may suggested that the adsorption is endothermic, spontaneous and Physisorption. The inhibitor follows Langmuir adsorption isotherm. (The average Regression Coefficient value 0.9917) The corrosion products formed on the metal surface was analyzed by using various spectroscopic studies FT-IR, EDX and XRD techniques and the film formation also confirmed by SEM image.

Keywords: Mild Steel, ESBL, mass loss, adsorption, spectral studies.

1.INTRODUCTION

The most commonly used base metals in today's manufacturing industry are mild steels as per the ASTM Standard. These steels, which have a carbon content of up to 2.1% by weight,

have an astonishing variety of uses. They are used in the oil and gas industries, mining and construction, power plants, and transportation, including shipping. These steels are cheap, readily available and easy to work with, but they have one serious disadvantage, It is corroded easily when they are exposed to water or dilute acid environments. Corroded steel loses strength and becomes hazardous, so it needs to be replaced promptly. This, in turn, greatly increases the cost of many industrial processes in oil drilling, power generation and many other industries. The established method of dealing with corrosion involves applying a chemical inhibitor. However, most of the corrosion inhibitors in regular use have problems—they may be toxic, carcinogenic, or difficult to dispose of. In order to overcome these difficulties, the search one that is environmentally friendly and safe to use.[1] The recent years literature reveals that the study of corrosion inhibition of different metals with various green inhibitor have been reported. A few investigations are Red Peanut Skin[2], Musa species peels[3], *Vernonia Amygdalina*[4], *Piper guinensis* [5], Henna extract[6], *Delonix regia* extracts[7], Rosemary leaves[8], natural honey[9], *opuntia* extract[10], khillah (*Ammi visnaga*) seeds[11], *Carica Papaya* and *Camellia Sinensis* Leaves[12], *Ricinus communis* Leaves[13], *Justicia gendarussa*[14], *Vitis vinifera*[15], *Punica granatum* peel[16], Leaves of *Genus Musa*, *Genus Saccharum* and *Citrullus Lanatus*[17], *mimusops elengi* leaves [18], *Sauropus Androgynus* Leaves [19], *Kingiodendron Pinnatum* Leaves [20], *Tephrosia Purpurea*[21], *Tephrosia Purpurea* [22], *Lagenaria Siceraria Peel Extract*[23], *Couroupita Guianensis* Flower[24], *Stachytarpheta jamaicensis*[25], *Jatropha gossyfolia*[26], *Eleaocarpus Serratus* Leaf[27], *Toddaliaasatica* leaf[28] have been studied on various metals and their alloys. In continuous of our research work, our present investigation is Application of "Eugenia Singampattiana Beddome" leaves on Mild steel in Natural Sea Water by various periods of contact and temperature using the mass loss and Electrochemical methods. The corrosion product formed on the metal surface is analysed by UV-Visible, FT-IR, EDX, XRD and the morphological studies by SEM-image.

2. MATERIALS

2.1 Preparation of Test Specimen

Rectangular specimen of Mild steel was mechanically pressed, cut to form different coupons, each of dimension exactly 20cm^2 ($5 \times 2 \times 2\text{cm}^2$) abraded with emery wheel of 80 and 120 and degreased using trichloroethylene, washed with distilled water, cleaned and dried, then stored in desiccator for throughout our present study.

2.2 Stock solution of *Eugenia Singampattiana Beddome*

About 3 Kg of *Eugenia Singampattiana* Beddome leaves was collected from in and around Western Ghats and then dried under shadow for 5 to 15 days. Then it is grained well and finely powdered, exactly 150g of this fine powder was taken in a 500ml round bottom flask and a required quantity of ethyl alcohol was added to cover the fine powder completely, and left it for 48 hrs. Then the resulting paste was refluxed for about 48 hrs, the extract was collected and the excess of alcohol was removed by the distillation process. The obtained paste was boiled with little amount of activated charcoal to remove impurities, the pure plant extract was collected and stored.

2.3 METHODS

2.3.1 Weight loss studies

Mild steel specimen were weighed initially and immersed in 100ml of test solution for 24 to 360 hours at the room temperature in the presence and absence of ESBL inhibitor and the temperature studies was also carried out ranges from 303K to 333K for an hour. At the end of exposure period, specimens were washed and their final weight was recorded. The experiment was conducted in triplicates to avoid the error during analysis. From the mass loss measurements, corrosion rate was calculated using the following relationship: From the mass loss measurements, the corrosion rate was calculated using the following relationship.

$$\text{Corrosion Rate(mmpy)} = \frac{87.6 \times W}{DAT} \quad \text{----- (1)}$$

Where, mmpy = millimeter per year, W = Mass loss (mg), D = Density (gm/cm³),
A = Area of specimen (cm²), T = time in hours.

The inhibition efficiency (%IE) and degree of surface coverage (θ) were calculated using the following equations.

$$\% IE = \frac{W_1 - W_2}{W_1} \times 100 \quad \text{-----(2)}$$

$$\theta = \frac{W_1 - W_2}{W_1} \quad \text{----- (3)}$$

Where W_1 and W_2 are the corrosion rates in the absence and presence of inhibitor respectively.

3.RESULTS AND DISCUSSION

3.1 Mass loss Technique

3.1.1 Effect of Concentration

The dissolution behavior of Mild Steel in Natural Sea Water containing different concentration of *Eugenia Singampattiana Beddome* leaves (ESBL) extract with exposure time from (24 to 360hrs) are shown in Table -1.

Observed values of corrosion rate markedly increased with increase of exposure time and decreased (from 0.1859 to 0.0464 mmpy) with increase of inhibitor concentration upto 120hrs but beyond that the corrosion rate decreased. The degree of surface coverage is increased from 0.1250 to 0.7500 and the percentage of inhibition efficiency is also increased with increase of inhibitor concentration. Since there is a direct relationship between the degree of surface coverage and the percentage of inhibition efficiency. The maximum of 95.24% of inhibition efficiency is achieved at 1000ppm inhibitor concentration after 120 hrs exposure time. This

achievement is mainly due to the addition of important active phyto chemical constituent in the inhibitor molecule which is interact with the metal surface and shield completely to prevent further dissolution from the aggressive media.

Table-1: Calculated values of corrosion rate and inhibition efficiency (%) Using different concentration of *ESBL* on Mild steel in Natural sea water

Con. of inhibitor (ppm)	24 hrs		72 hrs		120 hrs		240 hrs		360 hrs	
	C.R	% I.E	C.R	% I.E	C.R	% I.E	C.R	% I.E	C.R	% I.E
0	0.1859	-	0.0929	-	0.2929	-	0.6742	-	0.1332	-
10	0.1627	12.50	0.0542	41.67	0.1255	57.14	0.3115	53.79	0.0836	37.21
50	0.0929	50.00	0.0464	50.00	0.0371	87.30	0.2371	64.82	0.0759	43.02
100	0.0697	62.50	0.0232	75.00	0.0278	90.47	0.1232	81.72	0.0371	72.09
500	0.0464	75.00	0.0232	75.00	0.0185	93.65	0.0906	86.55	0.0325	75.58
1000	0.0464	75.00	0.0154	83.34	0.0139	95.24	0.0464	93.10	0.0216	83.72

3.1.2 Effect of Temperature:

The dissolution behavior of Mild steel containing various concentration of *ESBL* extracts in Natural Sea Water with temperature range from 303K to 333K and the observed values are listed in Table -2. The value of inhibition efficiency is decreased with rise in temperature (303K to 333K) is due to the adsorption of active inhibitor molecules on the metal surface is higher than the desorption process. It is evident that the inhibitor follows Physisorption process.

Table-2: Effect of temperature on the corrosion of Mild steel in the presence and absence of various concentration of ESBL inhibitor in Natural sea water

Con. of inhibitor (ppm)	303 K		313 K		333 K	
	C.R	% I.E	C.R	% I.E	C.R	% I.E
0	22.3184	-	30.1299	-	31.2458	-
10	20.0866	10.00	26.7821	11.11	28.4560	8.93
50	17.8547	20.00	24.5503	18.51	26.2242	16.07
100	16.1808	27.50	21.2025	29.62	22.8764	26.79
500	12.8331	42.50	17.8547	40.74	21.2025	32.14
1000	8.3694	62.50	15.0649	50.00	17.8547	42.86

3.1.2.1 Corrosion Thermodynamic Parameters

$$CR = A \exp(-E_a/RT) \text{----- (4)}$$

$$\log CR = \log A - E_a/RT \text{----- (5)}$$

$$CR = RT/Nh \exp(\Delta S/R) \exp(-\Delta H/RT) \text{----- (6)}$$

where CR is the corrosion rate, E_a is the apparen tactivation energy, R is the universal gas constant ($8.314 \text{ Jmol}^{-1} \text{ K}^{-1}$), T is temperature, A is the Arrhenius pre exponential factor, h is the Plank's constant ($6.626176 \times 10^{-34} \text{ J/s}$), N is the Avogadro's number ($6.02252 \times 10^{23} \text{ mol}^{-1}$), ΔS is the entropy of activation and ΔH is the enthalpy of activation

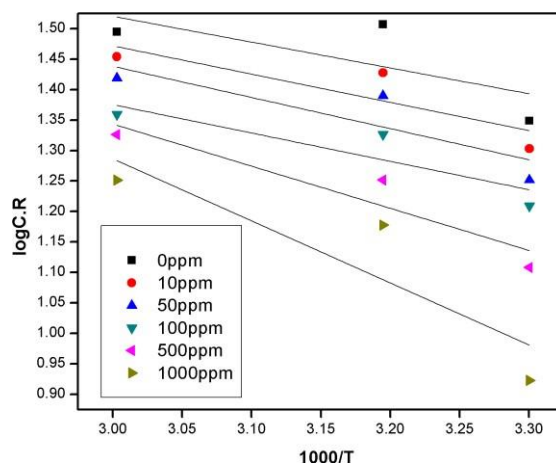


Fig.1. Arrhenius plot of Mild steel in Natural Seawater in the absence and presence of different concentration of ESBL

A plot of log (CR) obtained by weight loss measurement versus 1/T gave straight line with

average regression co-efficient (R^2) value close to unity as shown Fig.1. It is evident from the Table- 3. that the apparent energy of activation increased on addition of ESBL in comparison to the uninhibited solution. This values ranged from 9.41 to 21.19 kJmol^{-1} and are lower than the threshold value of 80 kJ/mole required for Chemical adsorption. This shows that the adsorption of ethanol extract of inhibitor on mild steel surface is Physical adsorption.

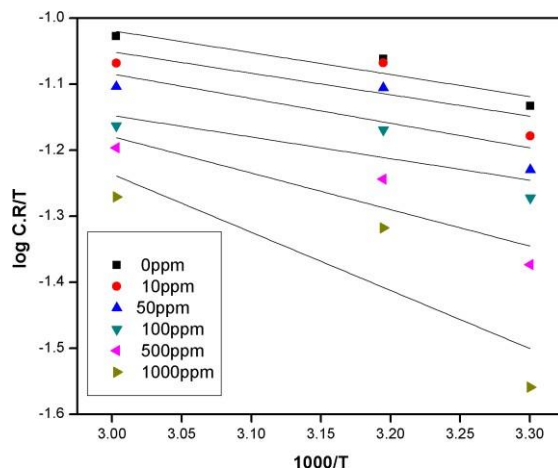


Fig.2 Transition state plot for Mild steel corrosion in NSW in the absence and presence of different concentration of ESBL.

The transition state equation was used to evaluate some thermodynamic parameters (ΔH , ΔS) for the adsorption of inhibitor on the Mild steel surface. The plot of $\log (CR/T)$ against $1/T$ was linear, the slopes and intercept of the transition state plot (Fig.2) are equal to $(-\Delta H/2.303R)$ and $(\log R/Nh+\Delta S/2.303R)$, respectively. The values of ΔS and ΔH were determined using a plot of $\log (CR/T)$ vs. $1000/T$ and are shown in Table-3. The positive value of enthalpy of activation indicates that the endothermic nature of the dissolving process is very difficult. The entropy (ΔS) is generally interpreted with disorder which may taking place on going from reactants to the activated complex.

Table 3: Corrosion Thermodynamic parameters of ESBL in Natural sea water on Mild steel

S.No	Concentration of ESBL (ppm)	E_a (kJmol^{-1})	ΔH (kJ mol^{-1})	ΔS ($\text{JK}^{-1}\text{mol}^{-1}$)
1	0	9.41	6.3626	80.4682
2	10	9.74	6.2343	80.4160
3	50	10.75	7.1515	80.5261
4	100	9.68	6.2400	80.3205
5	500	14.04	10.592	80.9704
6	1000	21.19	16.8648	81.8961

3.1.2.2 Adsorption Isotherm

The mechanism of corrosion protection was explained on the basis of adsorption behavior. Adsorption isotherms are very important in determine the mechanism of organo electrochemical reaction. The adsorption of organic compounds happens due to the interaction energy between the inhibitor and a metallic surface either through electrostatic or covalent bond formation. In order to gain adsorption isotherms, the surface coverage(θ) gained by the function of inhibitor's concentration. The data of θ are then graphed to fit the more appropriate adsorption model such as, Langmuir, Temkin, Frumkin, Flory- Huggins, Freundlich, and the El-Awady and best results judged by the correlation coefficient R^2 are listed in Table-4.

The Langmuir adsorption isotherm can be expressed by the following Equation is given below,

$$\log C/\theta = \log C - \log K \text{-----} (7)$$

Where θ is the degree of surface coverage, C is the concentration of the inhibitor solution and K is the equilibrium constant of adsorption of inhibitor on the metal surface.

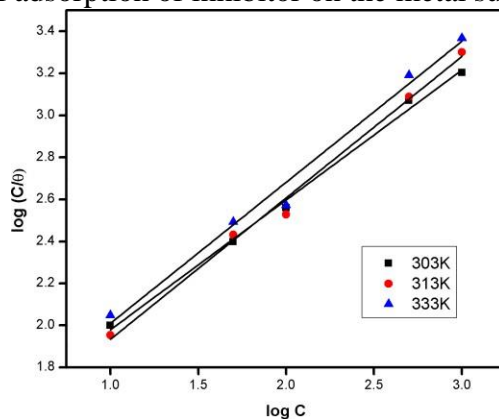


Fig.3: Langmuir adsorption plot for ESBL on Mild steel in Natural sea water.

Plotting of $\log C/\theta$ against $\log C$ is shown in Figure 3. Straight line slope with unity indicating Langmuir adsorption isotherm. Langmuir isotherm assumes that the metal surface contains a fixed adsorption sites and each site holds one adsorbate. Since the average regression coefficient is almost unity (0.9917), the adsorption behavior is believed to obey Langmuir adsorption isotherm at all the studied temperature. This indicates that mono-layer of the studied inhibitor adsorbed to Mild steel surface without interaction between the adsorbed molecule.

Table.4 Adsorption Isotherms values for Mild steel in Natural sea water with different concentration of ESBL extract

Isotherm	Temperature	R^2	log K	Slope value
Langmuir	303K		1.3607	0.6184

	313K	0.9917	1.2609	0.6732
	333K		1.3378	0.6718
Temkin	303K	0.9344	-0.1913	-4.6375
	313K		-0.1070	-5.8840
	333K		-0.0850	-7.0731
Florry-Huggins	303K	0.8098	-2.0712	3.0336
	313K		-1.8131	5.1647
	333K		-2.1399	3.8072
Frumkin	303K	0.9548	-0.0946	2.9543
	313K		-0.2209	3.6193
	333K		-0.2489	4.2012
Freundlich	303K	0.9591	-1.3607	0.3816
	313K		-1.2609	0.3268
	333K		-1.3384	0.3285
El-Awady	303K	0.9637	-1.5329	1.7995
	313K		-1.3551	2.2168
	333K		-1.4054	2.3557

3.2 ELECTROCHEMICAL STUDIES

3.2.1 Polarization measurements

In Fig. 4, Potentiodynamic anodic and cathodic polarisation plots for Mild steel specimens in natural sea water are depicted in both the absence and presence of various doses of ESBL extract. Table.5 lists the relevant kinetic parameters, such as the corrosion potential (E_{corr}), cathodic tafel slope (b_c), anodic tafel slope (b_a), and inhibition efficiency (IE%). The information in Table .5 shows how adding ESBL extract reduces corrosion current density. Also, it can be clearly seen that the inhibition efficiency of ESBL extract increases with inhibitor concentration. This behavior shows that ESBL extract acts as a good inhibitor for the corrosion of Mild steel in Natural Sea water. Moreover, in the presence of ESBL extract the values of corrosion current density from 3443 to 733 $\mu\text{A cm}^{-2}$ with increase of inhibitor concentration (from 0ppm to 1000ppm).It is evident from Table .6 that the addition of ESBL shows a positive shift in the E_{corr} value shift in the corrosion potential exceeds $\pm 85\text{mv}$ with respective corrosion potential of the uninhibited solution, the inhibitor act as either anodic or cathodic type. In the present case the corrosion potential (E_{corr}) was shifted to positive direction (from -633.3 to -566.9 mV). Therefore ESBL extract could be classified as cathodic type inhibitor.

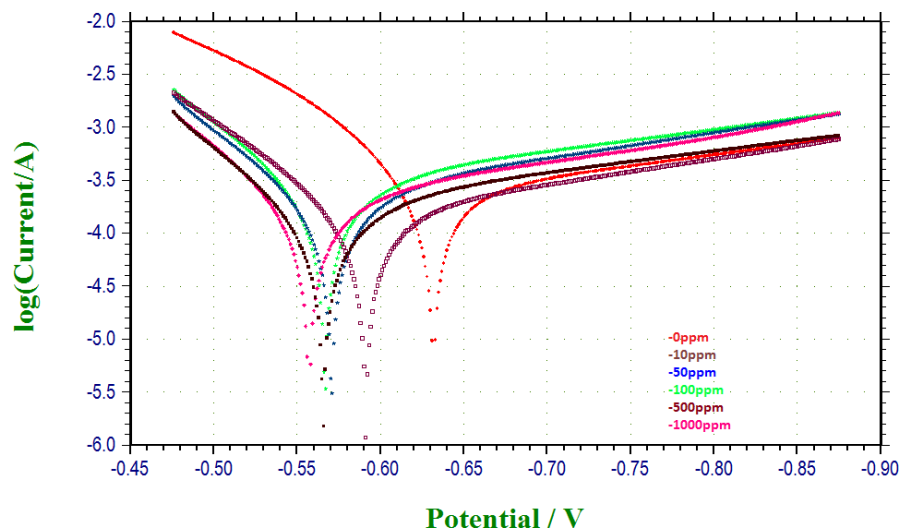


Fig.4. Polarisation curves for Mild Steel in Natural Sea Water containing various concentration of ESBL inhibitor.

3.2.2 Electrochemical Impedance (EIS) studies

The corrosion behaviour of Mild steel in naturally occurring sea water in the presence of ESBL extract was investigated using EIS measurements. The Nyquist representation in Fig. 5 shows that the results of EIS experiments. According to an investigation of the Nyquist plots, the diameter of the plots (R_{ct}) grows as the concentration of ESBL extract does. These results suggest that the ESBL extract behaves as a Mild steel corrosion inhibitor in natural sea water. The charge transfer resistance (R_{ct}), double layer capacitance (C_{dl}), inhibitory efficiency (IE%), and other impedance parameters are listed in Table- 5.

Careful inspection of this data revealed that the value of Charge transfer resistance R_{ct} increases from 4.469 to 15.219 $\Omega \text{ cm}^2$ of Mild steel in Natural sea water with increase of inhibitor concentration. The inhibition efficiency increased from 35.86 to 70.83 %. It ensures that the formation of protective film on the metal surface. The double layer capacitance C_{dl} decreases from 56.72 to 8.72 Fcm^2 with the increase of ESBL extract concentration may be due to adsorption of the active compounds on the metal surface leading to a film formation. The increase in the polarization resistance leads to an increase of inhibition efficiency. The results indicate good agreement between the values of corrosion efficiency as obtained from the impedance technique and polarization measurements. Since it was able to resist the attack of corrosion environment in Mild steel. It can be noticed that the nodal plane clearly indicated that the charge transfer process may controlling the dissolution of the metal. This data was also fitted with the values obtained from the mass loss data as described earlier.

The Bode impedance plots (Fig.5(b)) reflected that the value of charge transfer resistance (R_{ct}) increased with increase of inhibitor concentration and suggested that the protective film formed on the metal surface was more stable.

Table- 5.Parameters derived from electrochemical measurements of Mild steel in Natural Sea water containing various concentration of ESBL inhibitor.

Conc. (ppm)	Polarisation studies					Impedance studies		
	$-E_{corr}$ mV/dec	b_a (mV/ dec)	b_c (mV/ dec)	I_{corr} $\mu A\ cm^{-2}$	I.E (%)	R_{ct} ($\Omega\ cm^2$)	$C_{dl}\ x10^{-4}$ Fcm^2	I.E (%)
Blank	633.3	9.29	2.46	3443	---	4.469	56.72	---
10	568.0	12.34	3.04	2379	30.90	6.968	30.51	35.86
50	570.8	12.58	3.26	1848	46.32	7.788	28.42	42.61
100	592.9	10.86	2.92	1542	55.21	10.279	16.23	56.52
500	557.5	20.83	10.53	881	74.39	10.456	16.20	57.25
1000	566.9	19.18	9.32	733	78.75	15.219	8.72	70.63

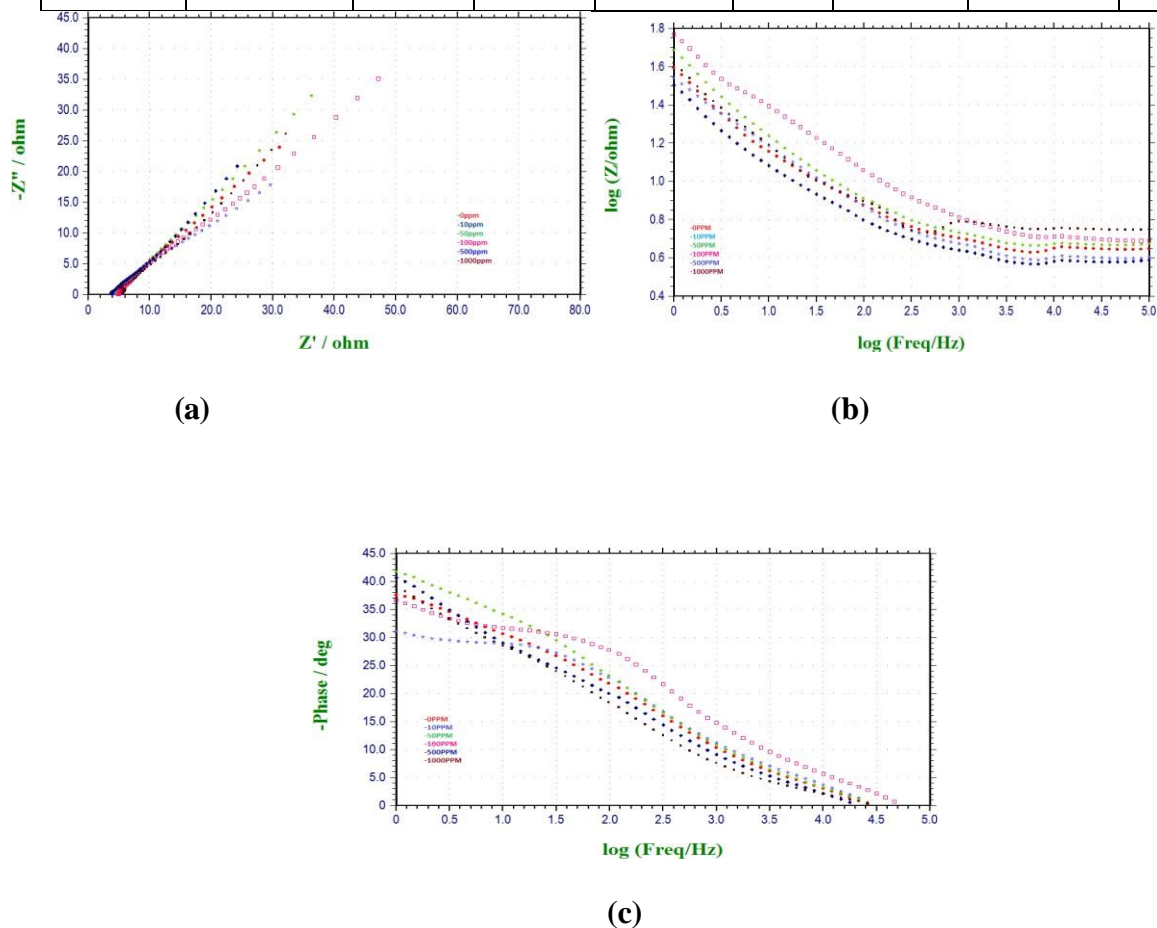


Fig.5 (a-c). Electrochemical impedance plots, (a) Nyquist, (b) Bode plot, (c) Phase angle plot for Mild Steel in NSW containing various concentration of ESBL inhibitor.

3.3 Characterization Studies of Corrosion Products

3.3.1 FT-IR Analysis

The figures- 6 (a) and (b) reflect that the FT-IR spectrum of the ethanolic extract of inhibitor and the corrosion product on Mild Steel in the presence of ESBL extract in Natural Sea Water. On comparing both of the spectra the prominent peak such as, the -OH stretching frequency for acids is shifted from 2939.52 to 3421.72 cm^{-1} , the -C=O stretching in carbonyl is shifted from 1693.50 cm^{-1} to 1635.54 cm^{-1} . The -C-O stretching frequency for ether is shifted from 1039.63 to 1116.78 cm^{-1} . These results also confirm that the FT-IR spectra support the fact that the corrosion inhibition of ESBL extract on Mild Steel in Natural Sea Water may be the adsorption of active molecule in the inhibitor and the surface of metal.

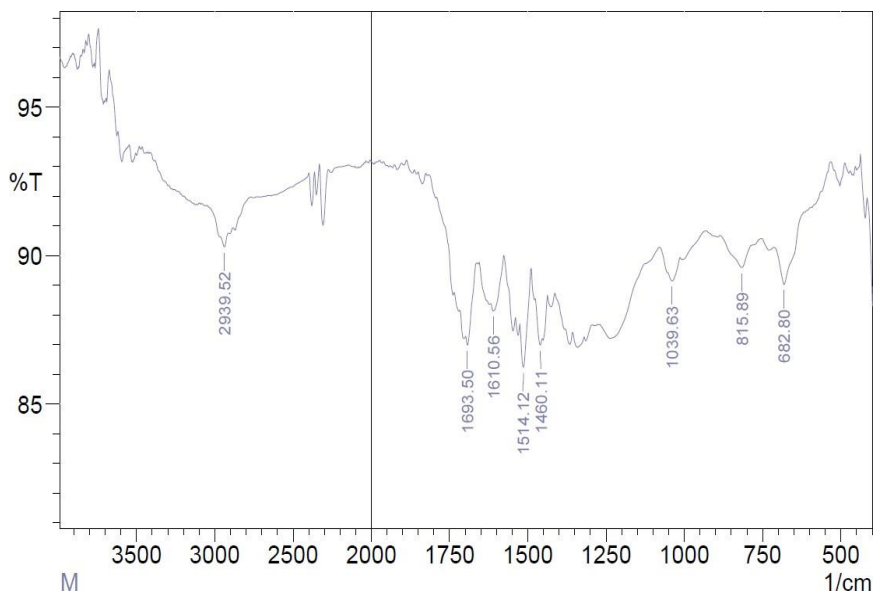


Figure 6(a): FT-IR spectrum of ethanolic extract of *Eugenia singampattiana* Beddome leaves (ESBL)

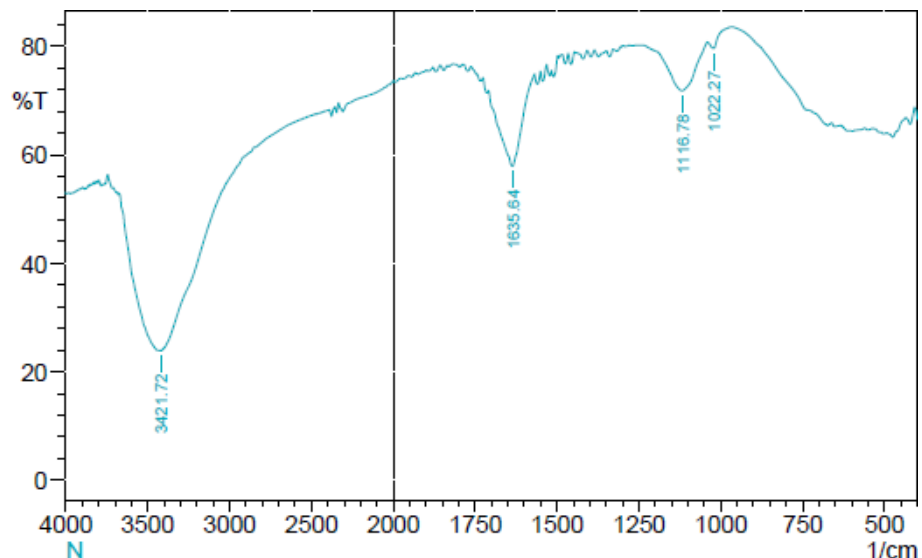


Figure. 6(b): FT-IR spectrum for the corrosion product on Mild Steel in the presence of ESBL extract with Natural Sea Water.

3.3.2 EDX Spectrum:

EDX spectroscopy was used to determine the elements present on the Mild Steel surface in the absence and presence of inhibitor. Fig.7(a) and (b) represents the EDX spectra for the corrosion product on metal surface in the absence and presence of optimum concentrations of ESBL extract in Natural Sea Water. In the absence of inhibitor molecules, the spectrum may concluded that the existence of carbon in the metal. However, in the presence of the optimum concentrations of the inhibitors, sulphur and oxygen atoms are found to be present in the corrosion product on the metal surface. It is clearly indicate that these hetero atoms present in the inhibitor molecules may involve the complex formation with metal atom during the adsorption process and prevent the further dissolution of metal against corrosion.

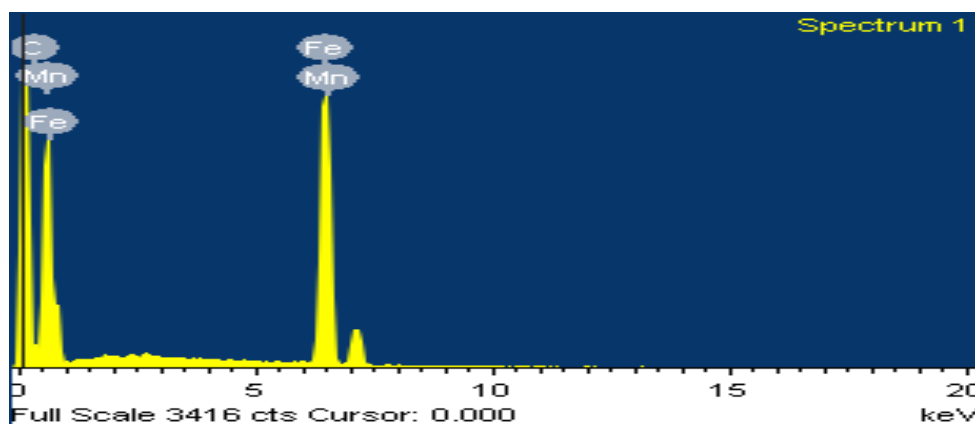


Fig. 7(a) : EDX spectrum of the corrosion product on Mild Steel surface in Natural Sea Water.

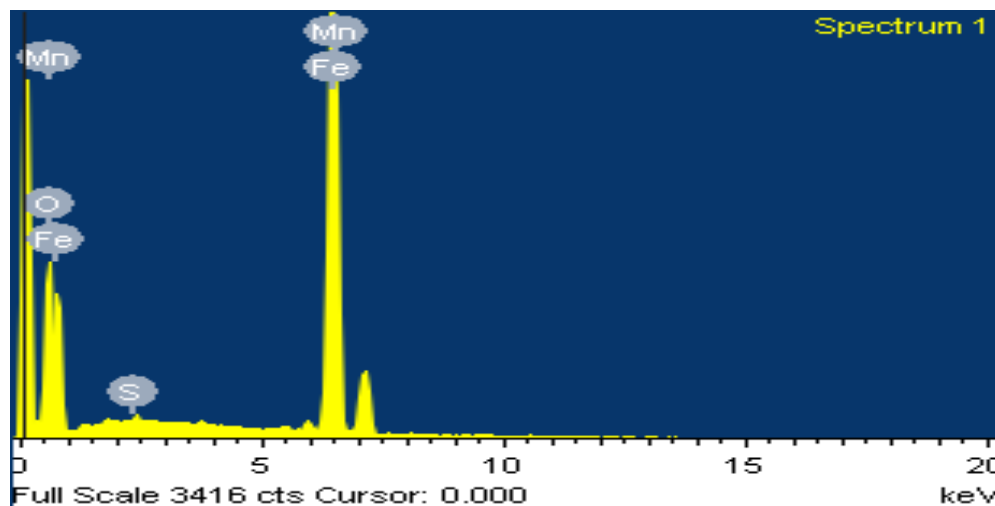


Fig.7(b): EDX spectrum of the corrosion product on Mild Steel in the presence of ESBL extract in Natural Sea Water.

3.3.3 SEM Analysis

The surface morphology of Mild Steel surface was studied by scanning electron microscopy (SEM). The Figure-8 (a) and (b) shows the SEM micrographs of Mild Steel surface before and after immersion in Natural Sea Water respectively. The SEM photographs (a) showed that the surface of metal has number of pits and cracks are visible in the surface, it may be the plug type of corrosion but in presence of inhibitor the dissolution process significantly reduced by the formation spongy mass covered the entire surface of the metal completely.

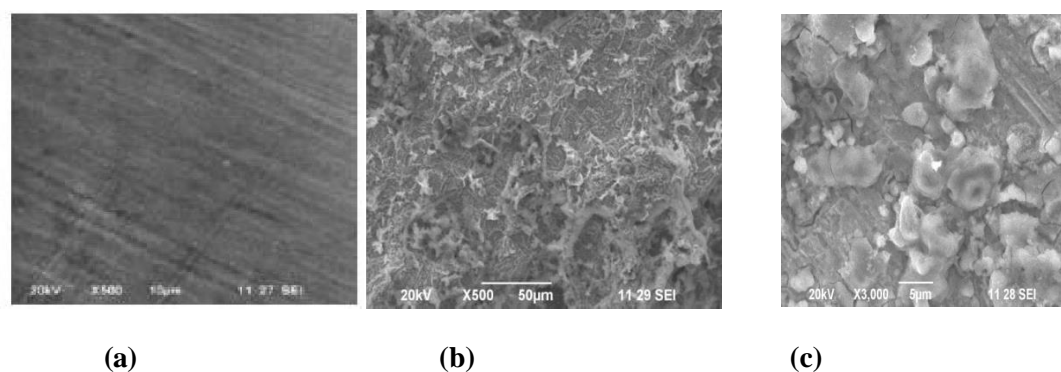


Figure 8: SEM images of the Mild Steel surfaces: (a) Polished metal (b) immersed in Natural Sea Water (c) immersed in Natural Sea Water with ESBL extract.

3.3.4 XRD Spectral analysis

The X-ray diffractogram of inhibitor, corrosion products formed on Mild steel in absence and presence of inhibitor molecules shown in Fig.9 (a-b). The corresponding corrosion product

shows mainly characteristic peak at 2θ values of 21.2, 33.1, 36.2, 41.3, 53.2, 59.1 corresponding to the (110), (130), (111) and (210), (131), (211) planes of goethite

α - FeO(OH)] with JCPDS File Card no.03 – 0249. When Mildsteel exposed over long period of contact with produced water the corresponding peaks were observed at 2θ values of 15.2, 22.3 and 31.4 corresponds to the (104), (124) and (119) planes of hematite – Fe₂O₃ [JCPDS File Card no.33 – 0664]. The peak at 2θ value of 16.1, 18.1, 23.3 and 27.2 corresponds to (110), (112), (114), and (115) planes of the Ferrihydrite – Fe₅O₇(OH)_x.4H₂O [JCPDS File Card no.29 – 0712], akaganeite – β -FeO(OH) [JCPDS File Card no.34 -1266] and lepidocrocite [(γ – FeO(OH)] with JCPDS File Card no. 29 – 713. Due to presence of high concentration of NaCl rich amount of following crystalline compounds namely the orthorhombic structure of [H₃O (H₂O)₅ Fe] Cl₄ (JCPDS File number 78-1926) formed on the Mildsteel surface.

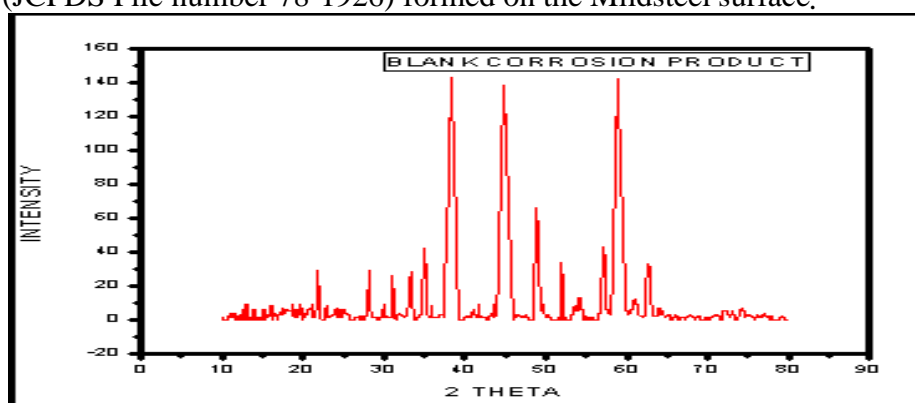


Fig. 9 (a) XRD spectrum of corrosion product on Mild steel in the absence of ESBL inhibitor in Natural Sea water

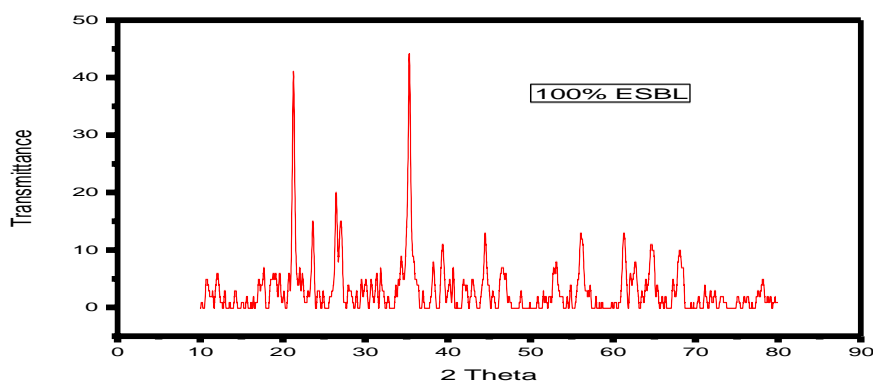


Fig. 9 (b) XRD spectrum of corrosion product on Mild steel in the presence of ESBL inhibitor in Natural Sea water

6. CONCLUSION

Eugenia Singampattiana Beddome leaves has shown excellent inhibition performance for Mild Steel in Natural Sea Water environment. The inhibition efficiency increased with the

increase of inhibitor concentration. The maximum inhibition efficiency was achieved 95.24%. Also, the inhibition efficiency gradually decreased with the rise in temperature ie, 62.50% to 42.86% for 303K and 333K respectively. This is due to the adsorption of active inhibitor molecules on the metal surface is higher than desorption process. It follows physisorption mechanism. The value of activation energy (E_a), enthalpy of adsorption (ΔH_{ads}) and entropy change (ΔS) indicates that the adsorption of inhibitor on metal surface follows endothermic and spontaneous process respectively. The inhibitor is found to obey Langmuir adsorption isotherm(0.9917). In polarisation studies the value of I_{corr} decreased from 3443 to 733 $\mu A/cm^2$ and the maximum of 78.75% I.E was arrived in the presence of inhibitor and the corrosion potential (E_{corr}) was shifted to positive direction (from 633.3 mV to 566.9mV). Therefore ESBL extract could be classified as cathodic type inhibitor. The R_{ct} values increased from 4.464 to 15.219 Ωcm^2 with increase of inhibitor concentration and the maximum of 70.63% of I.E was attained. The analysis of corrosion composite by using EDX, FT-IR and image of SEM clearly revealed that the formation of the strong protective thin film.

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