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The Comparison Study of *Commiphora Berryi* and *Salvia Rosmarinus* Leaf Extracts as Green Corrosion Inhibitors on Mild Steel in 1N Hcl Medium.

G. T. Parethe[1*], P. Rajesh[1], M. Balaji[1], S. Kavica[1] and M. Ezhlil Inban[2]

[1] Department of Chemistry, Government Arts College (Autonomous), Coimbatore-641018.
[2] Department of Physics, Government Arts College (Autonomous), Coimbatore-641018.

ABSTRACT

The leaf extracts have been generally used to safe the metal materials from corrosion. The use of leaf extracts as green corrosion inhibitors is an executable source. The execution of these extracts as corrosion inhibitors is frequently assessed through electrochemical studies, which includes electrochemical impedance spectroscopy, potentiodynamic polarization and weight loss measurement. The inhibition efficiency of numerous concentrations of leaf extracts acts as a main indicator to obtain an understandable outlook of an extracts for a particular purpose. The current analysis concentrates on the green corrosion inhibitors using *Commiphora berryi and Salvia Rosmarinus* leaf extracts in controlling corrosion of mild steel in 1N HCl. Results from the test manifested that *Salvia Rosmarinus* leaf extracts attained highest inhibition efficiency at 80.93% while *Commiphora berryi* recorded highest inhibition efficiency at 79.34% in HCl environment. The test implemented, that specified both *Commiphora berryi* and *Salvia Rosmarinus* have inhibitive efficiency in 1N HCl environment with *Salvia Rosmarinus* leaf extract performing slightly better than *Commiphora berryi* leaf extracts.

Key words: Mild steel, 1N HCl, leaf extracts.

1. Introduction:

The metals are extensively used in day-to-day activities because of their unique mechanical as well as their electrical behaviours [1]. Preventing the metals from corrosion is a principal need. Corrosion is a foremost phenomenon in which metal surfaces are oxidised due to environmental features. Among metals, mild steel is most repeatedly used due to their extraordinary mechanical properties. Many studies have been performed related to the corrosion of steel. The corrosion inhibitors that are used be made up of organic compounds such as oxygen, nitrogen and sulphur. These organic compounds are examined to be harmful, non-renewable and costly that is hazardous to human health and environment. Thus, leaf extracts as corrosion inhibitors have attracted many researchers. The different plant part extracts like stem, leaves, root, seed and flower can be used as corrosion inhibitors [2A, 2B].

Commiphora berryi belongs to Burseraceae family is called as Indian Balm of Gilead is a fragrant and throny tree. The tree is used in folklore medicine as an ingredient due to their medicinal properties. The parts plant used as astringent, antiseptic, diuretic medicinal formulations

Figure 1: *Commiphoraberryi*

Salvia rosmarinus belongs to Lamiaceae family commonly known as Rosemary, is a shrub with fragrant, evergreen, needle like leaves. It is a member of sage family which includes many medicinal uses. Rosemary contains a number of phytochemicals such as rosmarinic acid, Camphor, Caffeic acid and carnosol [3].

Figure 2: *Salvia Rosmarinus*

Based on the literature survey, no previous work has been reported on the corrosion inhibition of *Commiphora berryi* and *Salvia rosmarinus* leaf extracts for mild steel in 1N HCl medium.

For this purpose, Tafel polarisation measurements and impedance studies were carried out.

2. EXPERIMENTAL PROCEDURE:

2.1 Materials:

2.1.1 Mild steel Specimen:

Weight loss measurements and electrochemical studies were carried out on mild steel having the dimensions of 5 cm x 2 cm x 0.1 cm and having the area of 1cm^2. The contaminants existing on the steel were eliminated using emery sheet, distilled water.

Table 1: Composition of Mild steel: **[4]**

Elements	C	P	Cr	Ni	Mo	Mg	Mn
Weight(%)	**0.025**	**0.014**	**0.020**	**0.009**	**0.002**	**0.003**	**0.176**

2.1.2 Selection of mild steel:

i) Mild steel is chosen because they are economical and feasible.

ii) Green inhibitor (leaf extracts) are selected to avoid the corrosion of mild steel.

2.1.3 Preparation of 1N Hcl Solution:

8.33ml of Hcl solution were taken and made up to 100ml solution using distilled water.

2.1.4 Selection of acid medium:

1) Corrosion happens normally in acidic medium compared to alkaline (or) neutral medium.

2) Industrial activities has being grown extensively, Hcl are used in acidic pickling as performed in 1N Hcl solution.

2.1.5 Preparation of Inhibitors:

The fresh leaves of *Commiphora berryi* (CB) and *Salvia Rosmarinus* (SR) were collected, washed and dried in room temperature. The dried leaves were powdered. 24g of powdered leaves of each were mixed with 500ml of distilled water separately. The individual leaf extracts were allowed to boil for 2hours. Then the solutions were refluxed overnight and filtered. The filtrates were taken as stock solution

2.2 METHODS

2.2.1 Weight loss Method:

Weight loss measurement manifested that mild steel specimen in 1N Hcl solutions were inhibited by using many concentrations of leaves extracts. Each sample was weighed and immersed in the acidic medium. The experiment performed at the immersion period of 1, 12 and 24hours at room temperature. After immersion the outside surface of metals are washed with distilled water and samples are weighed to calculate the inhibition efficiency (%) and corrosion rate (CR). [8]

The Inhibition efficiency (%), surface coverage (Θ) were determined by using the below formula,

$$\Theta = W_o - W_t / W_\Theta \quad \textbf{(1)}$$

$$IE(\%) = W_o - W_t / W_o X\ 100 \quad \textbf{(2)}$$

Where W and W1 are weight loss in absence and presence of inhibitor corrosion rate of mild steel is calculated by the formula,

$$CR(mmpy) = k\ x\ weight\ loss\ /\ D\ x\ A\ x\ t\ (in\ hours) \quad \textbf{(3)}$$

Where k= 8.76x 10^4 [constant], D= Density in gm/cm^3,

W= weight loss in grams, A= Area in cm^2, [5]

2.2.2 FT-IR Spectra

FT-IR Spectra used to investigate the molecular composition and verify the biological macro molecules because it calculates the absorption energy. FT-IR spectrum (KBr pellets) of the surface film noted using Bruker alpha 8400 spectrophotometer having the wave number range of 4000-600 cm^{-1}.

2.2.3 Electrochemical studies

The method comprised of three electrode cell and mild steel performed as working electrode. The working electrode protected in a Teflon tube and beamed using sand paper. Silver and platinum electrodes were functioned as a reference and platinum electrode. A stabilization period of 1hour permitted for potentiodynamic polarization and electrochemical impedance technique. Corrosion current and other Tafel fit parameters were deliberated from Tafel polarization method. [6]

The inihibition efficiency calculated by the formula,

$$IE\ (\%) = I_{corr}(blank) - I_{corr}(inhibitor) / I_{corr}(blank)\ X\ 100 \quad \textbf{(4)}$$

Where, I_{corr} *(blank)* as corrosion current without inhibitor, I_{corr} *(inhibitor)* as corrosion current with inhibitor.

The double layer capacitance (cdl) were calculated by the formula,

$$Cdl = 1/2\pi f_{max} X R_{ct} \quad \textbf{(5)}$$

Where R_{ct} = charge transfer resistance and C_{dl} is double layer capacitance.

$$IE(\%) = R_{ct} - R^{o}_{ct} / R_{ct}\ X\ 100 \quad \textbf{(6)}$$

Where R_{ct} and R^{o}_{ct} are charge transfer resistance values in inhibited and uninhibited solutions [10]

3. RESULTS AND DISCUSSION

3.1 Characterisation and corrosion studies of Commiphora berryi Leaf extract:

3.1.1 Weight loss Method:

The mild steel was dipped in 1N Hcl acid at various concentrations of the extract for1,12 and 24 hours. The weight loss obtained from weight loss method was tabulated in the table. The tabulated values accurately showed that with the inclusion of rise in concentration of inhibitor, weight loss is controlled. The highest inhibition efficiency (78.5%) was reached at 25ml and concentration has been fixed to the best concentration of inhibitor.

Table:2 Corrosion Rate and Inhibition efficiency of *Commiphora berryi* Leaf extract

Commiphora berryi Leaf Extract	CR (mmpy)	IE (%)
Blank	**21.4585**	*
5	**8.0**	**62.5**
10	**6.2**	**70.8**
15	**6.1**	**71.5**
20	**5.1**	**76.0**
25	**4.5**	**78.5**

3.1.2 Immersion time:

Weight loss method in a simple and most commonly used method; generally they are used for identifying corrosion of metal in the dispersed medium. Inhibition efficiency and corrosion rate from immersion time were tabulated.

Table 3: Inhibition efficiency of *Commiphora berryi* Leaf extract in various immersion times.

Concentration of *Commiphora berryi* Leaf extract	Inhibition efficiency		
	1hour	12 hour	24 hour
5	**25.16**	**39.98**	**62.5**
10	**28.94**	**42.65**	**70.8**
15	**30.85**	**50.12**	**71.5**
20	**31.41**	**48.69**	**76.0**
25	**32.04**	**66.89**	**78.5**

3.1.3 FTIR Spectrum of Commiphora berryi leaf extract:

The prime structure of the inhibitor is not confirmed exactly through FTIR spectroscopy, but expecting the functional group is present. The IR absorption bands of inhibitors were stated in the figure. For *Commiphora berryi* leaf extract, bands are 3541 cm^{-1} could be designated to O-H group. The absorption band at 1589 cm^{-1} due to N-H bending group. The peak at 1085cm^{-1} due to C-O stretching group. The peaks below 1000cm^{-1} is due to aliphatic C-C, C-H group. The occupancy of all these groups related that the leaf extracts proceeded as a fine inhibitor by the way of absorption (or) protective layer evolved on the metal surface [9].

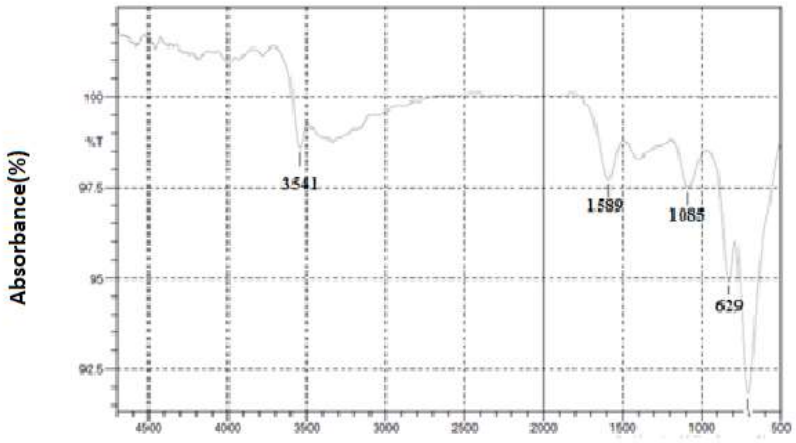


Figure 3: FTIR Spectra of *Commiphora berryi* leaf extract

3.1.4 Potentiodynamic polarization method:

The total curves of potentiodynamic polarization of mild steel in 1N Hcl by the extracts were manifested in figure and the values were outlined in table. It was notified that lowering of I_{corr} by raising the concentration of inhibitor. The highest IE% is visible at 25ml of *Commiphora berryi* Leaf extract. This showed that the extracts acted as a mixed type of corrosion inhibitor [11].

Table:4 The various parameters of Potentiodynamic polarization for *Commiphora berryi* Leaf extract:

Concentation of CB extract (ml)	E_{corr}(mv)	I_{corr} (mA/cm^2)	CR (mmpy)	b_c (mv/dec)	b_a (mv/dec)	IE(%)
Blank	**-546**	**2.37**	**1.333**	**189**	**120**	*
5	**-546**	**0.641**	**0.2628**	**161**	**95**	**72.95**
10	**-537**	**0.658**	**0.1492**	**143**	**89**	**72.23**
15	**-534**	**0.639**	**0.1422**	**152**	**85**	**73.03**
20	**-529**	**0.580**	**0.1029**	**145**	**116**	**75.52**
25	**-532**	**0.528**	**0.1093**	**149**	**128**	**77.72**

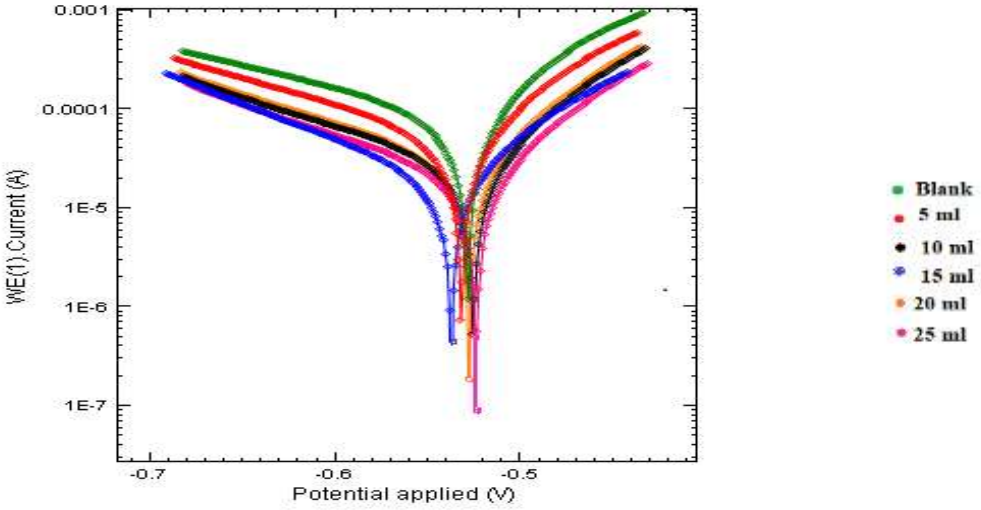


Figure 4: Polarization slope of mild steel in blank and various concentration of *Commiphora berryi* leaf extracts

3.1.5 Electrochemical Impedance spectroscopy:

The Nyquist interpretation conducted on mildsteel in 1N Hcl were shown in table and figure. It was detected that R_{ct} values has enhanced, the Cdl values has reduced with rise in concentration of *Commiphora berryi* leaf extracts [7]. The concentration at 25ml of *Commiphora berryi* leaf extract has highest inhibition efficiency.

Table 5: Measurement of impedance with blank and various concentration of *Commiphora berryi* Leaf extract in 1N Hcl

Concentration of *Commiphora berryi* leaf extract (ml)	Cdl (μFcm^{-2})	R_{ct} (Ωcm^2)	IE (%)
Blank	**3.733x10^{-5}**	**6.937**	*
5	**2.739x10^{-5}**	**20.09**	**65.47**
10	**3.659x10^{-5}**	**26.1**	**73.42**
15	**3.052x10^{-5}**	**27.94**	**75.17**
20	**3.373x10^{-5}**	**31.05**	**77.65**
25	**3.603x10^{-5}**	**33.58**	**79.34**

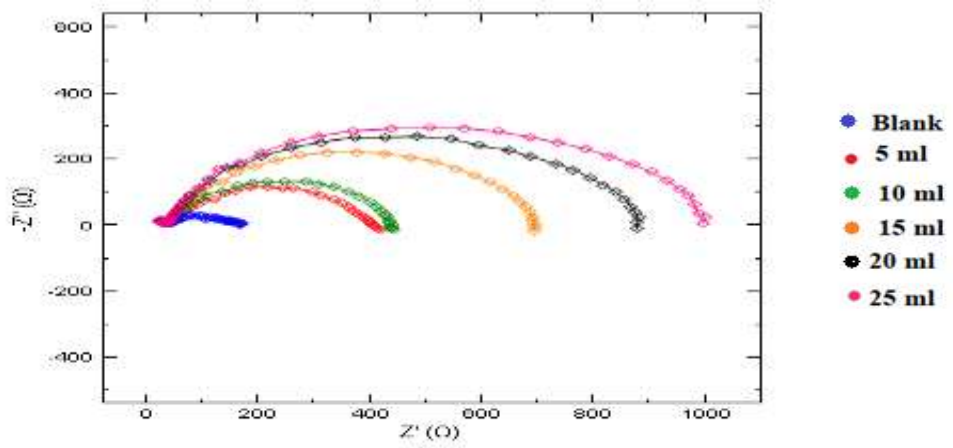


Figure 5: Impedance slope of mild steel in blank and various concentration of *Commiphora berryi* leaf extracts

4. Salvia Rosmarinus leaf extracts:

4.1.1 Weight loss method values:

The mild steel was dipped in 1N HCl acid at various concentrations of the extract for1,12 and 24 hours. The weight loss obtained from weight loss method was tabulated in the table. The tabulated values accurately showed that with the inclusion of rise in concentration of inhibitor, weight loss is controlled. The highest inhibition efficiency (80.93%) was reached at 25ml and concentration has been fixed to the best concentration of inhibitor [12].

Table 6: Corrosion Rate and Inhibition efficiency *Salvia Rosmarinus* Leaf extract

Salvia Rosmarinus Leaf extract	CR (mmpy)	IE (%)
Blank	**19.852**	*
5	**6.1**	**68.77**
10	**4.5**	**76.75**
15	**4.7**	**76.02**
20	**4.8**	**75.78**
25	**3.7**	**80.93**

4.1.2 Immersion time:

Weight loss method is a simple and most frequently used method; generally, they are used for verifying corrosion of metal in the dispersed medium. Inhibition efficiency and corrosion rate from immersion time were tabulated [13].

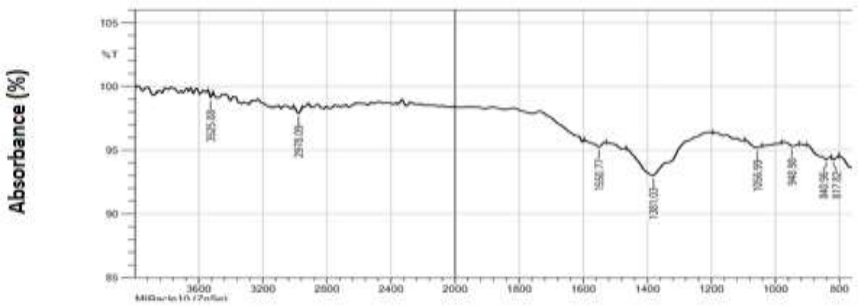
Table 7: Inhibition efficiency of *Salvia rosmarinus* Leaf extract in various immersion times.

Concentration of *Salvia rosmarinus* Leaf extract	Inhibition efficiency		
	1hour	24hour	12hour
5	**26.85**	**77.32**	**68.77**
10	**40.87**	**80.91**	**76.75**
15	**24.62**	**59.54**	**76.02**
20	**28.71**	**83.11**	**75.78**
25	**27.64**	**84.58**	**80.93**

4.1.3 FTIR Spectrum of Salvia rosmarinus leaf extract :

The predominant structure of the inhibitor is not confirmed exactly through FTIR spectroscopy, but expecting the functional group is present. The IR absorption bands of inhibitors were specified in the figure. For *Salvia rosmarinus* extract, bands are 3525.8cm^{-1} could be designated to O-H stretching,

the absorption band at 2978.09 cm^{-1} due to C-H bending group. The peak at 1550.7 cm^{-1} due to N-H bending group. The occupancy of all these groups related that plant related that plant extract acted as a good inhibitor by the way of absorption (or) protective layer developed on the metal surface [9].



Wavenumber(cm^{-1})

Figure 6: FTIR Spectrum of *Salvia rosmarinus* leaf extract

4.1.4 Potentiodynamic polarization method

The total curves of potentiodynamic polarization of mild steel in 1N HCl by the extracts were shown in figure and the values were summed up in table. It was observed that by lowering of I_{corr} by raising the concentration of inhibitor. The greatest IE% is noticed at 25ml of *Salvia Rosmarinus* leaf extract. This exhibited that the extracts acted as a mixed type of corrosion inhibitor [11].

Table 8: The various parameters of Potentiodynamic polarization for *Salvia Rosmarinus* leaf extract

Concentation of *Salvia Rosmarinus* extract (ml)	E_{corr}(mv)	I_{corr} (mA/cm^2)	CR (mmpy)	b_c (mv/dec)	b_a (mv/dec)	IE (%)
Blank	**-480**	**2.52**	**1.339**	**179**	**126**	*****
5	**-475**	**0.612**	**0.2541**	**165**	**98**	**75.71**
10	**-476**	**0.608**	**0.1140**	**151**	**115**	**75.87**
15	**-450**	**0.559**	**0.1094**	**147**	**112**	**77.81**
20	**-483**	**0.512**	**0.1094**	**147**	**102**	**79.68**
25	**-482**	**0.502**	**0.1094**	**147**	**102**	**80.07**

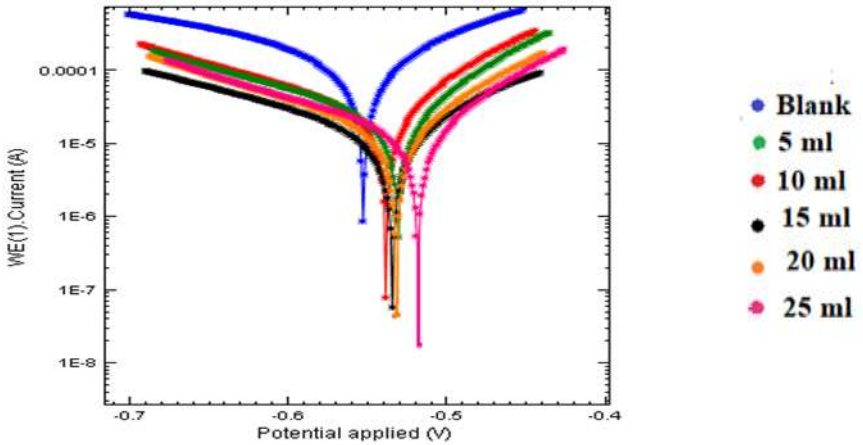


Figure7: Polarization slope of mild steel in blank and various concentration of *Salvia rosmarinus* leaf extracts

4.1.5 Electrochemical Impedance spectroscopy:

The Nyquist interpretation conducted on mildsteel in 1N HCl were shown in table and figure. It were identified that R_{ct} values has raised, the Cdl values has decreased with rise in concentration of *Salvia rosmarinus* leaf extracts [7]. The concentration at 25 ml of *Salvia rosmarinus* leaf extract as highest inhibition efficiency from impedance studies.

Table 9: Measurement of impedance with blank and various concentration of leaf extract in 1N HCl

Concentration of Salvia rosmarinus leaf extract (ml)	Cdl (μFcm^{-2})	R_{ct} (Ωcm^2)	IE(%)
Blank	**$3.614x10^{-5}$**	**6.437**	*
5	**$2.658x10^{-5}$**	**24.68**	**73.91**
10	**$3.629x10^{-5}$**	**25.44**	**74.69**
15	**$3.088x10^{-5}$**	**26.52**	**75.72**
20	**$3.347x10^{-5}$**	**27.85**	**76.88**
25	**$3.544x10^{-5}$**	**31.12**	**79.31**

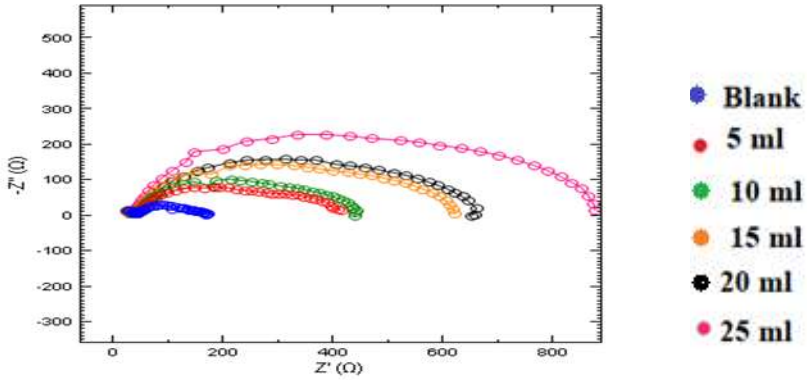


Figure 8: Impedance slope of mild steel in blank and various concentration of Salvia rosmarinus leaf extracts:

CONCLUSION:

The outcome of various concentrations of green extracts, namely *Commiphora berryi* and *Salvia rosmarinus* leaf extracts on the corrosion of mild steel in 1N HCl has been studied. The successive conclusion can be made depend on the results gained. The leaf extracts of two various plants showed good corrosion inhibition properties for mild steel in 1N HCl medium. The weight loss values specified that the inhibition efficiency of all these leaf inhibitors increase with increase in the concentration of the extracts and inhibits the corrosion of mild steel. Potentiodynamic polarization studies indicated that the extracts reacted as mixed type of inhibitor. Nyquist diagram obtained from impedance method disclosed that the charge transfer resistance (Rct) process controls the corrosion of mild steel. The mechanism involved in this study is the phytochemicals constituents exists in leaf extracts that have adsorbed on the mild steel surface forming a protective thin film and enhance the anticorrosive behaviour..The organic moieties present in the leaf extracts were also found in charge for the accomplishment of the inhibitor which was well supported by FTIR studies. For *Commiphora berryi* leaf extract, bands are 3541 cm^{-1} could be designated to O-H group. The absorption band at 1589 cm^{-1} due to N-H bending group. The peak at 1085cm^{-1} due to C-O stretching group. The peaks below 1000cm^{-1} is due to aliphatic C-C, C-H group. For *Salvia rosmarinus* extract, bands are 3525.8cm^{-1} could be designated to O-H stretching, the absorption band at 2978.09 cm^{-1} due to C-H bending group. The peak at 1550.7 cm^{-1} due to N-H bending group. Results obtained in weight loss method were very much fine agreement with the electrochemical impedance studies. The R_{ct} values has enhanced, the Cdl values has reduced with rise in concentration of *Commiphora berryi* leaf extracts and *Salvia Rosmarinus* leaf extracts. Among the two leaf extracts studied, the greatest inhibition efficiency is found in *Salvia rosmarinus* leaf extracts, which showed 80.93 % inhibition efficiency at 25 ml concentration of the extracts.

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