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Aqueous Extract of *Commelina Ensifolia* Leaves as Sustainable Green Inhibitor for Corrosion on Mild Steel in 1.0M H_2SO_4 Medium

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Abstract

The aqueous extract of *Commelina ensifolia* grown in Tamil nadu was examined for its corrosion inhibitive effect on the mild steel in 1.0 M H_2SO_4 medium using mass loss method. The work was analysing a process of less cost and eco-friendly also green inhibitor to minimize the mild steel corrosion rate. The plant extracts inhibited the corrosion of mild steel in acidic media through the adsorption of inhibitor on the surface of metal which prevent the mild steel from corrosion. The inhibition efficiency and surface coverage (θ) of leaves extract of *Commelina ensifolia* increases with increase in concentration of inhibitor. The maximum efficiency was observed to be 93.38% in 1.0 M H_2SO_4. The adsorption of leaves extract on mild steel surface was based to obey Tempkin isotherm. The value of free energy ($-\Delta G^0_{ads}$) indicated that the adsorption inhibitor molecule was typical of physisorption. The results obtained show that *Commelina ensifolia* leaves extract could act as an excellent environmentally friendly green corrosion inhibitor.

Keywords

Commelina ensifolia, Corrosion inhibitor, Mild Steel, Weight loss, Tempkin adsorption isotherm

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INTRODUCTION

Mild steel is known to be a very versatile ferrous alloy applied for a large scale of applications because of its outstanding combination of mechanical properties, low cost and perfect weldability [1]. Corrosion is a process, that converts a polished metal to extra stable form, for instance in the form of hydroxide or oxide. For electrochemical corrosion, the generation of iron oxides is a well-noted example for corroding. This sort of destroying is normally generating salts or oxides of the original metal, and outcomes in essential orange color. Inhibitor is a substance added in a very less concentration to handle the metal surface that exhibited to a corrosive surrounding that

stops the corrosion rate of a metal. The name inhibitor applies to the materials that have bio productivity in nature. The plant extracts inhibitors probably possess bio-productivity due to the origin of nature. Plant extracts constitute several organic compounds which have corrosion inhibiting abilities and also plant extracts are generally inexpensive and can be obtained through simple extraction processes [2]. The yield of these compounds as well as the corrosion inhibition abilities vary widely depending on the part of the plant and its location. Samsath and Naseer have explored the activity of an anti-detoriative using *Commelina ensifolia* leaves as green inhibitor on mild steel in 1.0 N HCl [3]. Antibacterial activity and corrosion inhibiting nature of mild steel in 1.0 M H_2SO_4 by M. piperita and M. pulegium essential oils have been evaluated by Chraibi et al. Reports displayed that essential oils play as a mixed-type inhibitor [4].

A summary of plants extracts used as corrosion inhibitors have recently been given in Rana et al. They noticed about the adsorption of all the three plant extracts on mild steel surface agreed both Langmuir and Tempkin adsorption [5]. Plant extracts used a corrosion inhibitor have been broadly analyzed and are introduced as an alternative to manmade organic compounds. Investigation of Alpinia galanga and its strong principle, 1'-acetochavicol acetate as environmental-friendly inhibitors of corrosion on mild steel in acidic medium has been finished by Ajeigbe et al [6]. Noreen Antony et al. have applied the extracts of diverse plant materials including henna leaves, curcumin, caffeine, spirulina to manage corrosion of metals [7]. Potentiodynamic polarization examinations revealed that the inhibitors acted as mixed inhibitors. Inhibition action of corrosion on carbon steel in 1 M HCl solution by Thapsia villosa extracts (Ethyl acetate extract (EAE) and butanolic extract (BE)) have been analyzed by Kalla et al. utilizing electrochemical impedance spectroscopy (EIS), potentiodynamic polarization and mass loss methods. The EAE and BE playing as a mixed types inhibitor. The extract on carbon steel surface obeys Langmuir isotherm adsorption [8]. In spite of the fact that a number of acute publications have been dedicated to corrosion inhibition by plant extracts, but the elaborate study of the adsorption mechanism is restricted and drawback of maximum of the publications on plant extracts as corrosion inhibitor is that more active component has not been determined. The present work is initiated to examine the inhibition efficiency of an aqueous extract of *Commelina ensifolia* leaves in preventing corrosion on mild steel in hydrochloric and sulphuric acid solutions. Mass loss measurements and electrochemical methods as in polarization and AC impedance spectra techniques have been applied.

EXPERIMENTAL METHODS

Extract of *Commelina ensifolia* leaves*:*

Extract of *Commelina ensifolia* leaves is applied as inhibitor for corrosion in the present work. The given below figure-1 shows the leaf *Commelina ensifolia.* Results of phytochemical screening of aqueous extract of *Commelina ensifolia* leaves was given in table-1

Figure 1: *Commelina ensifolia*

Details and medicinal uses of *Commelina ensifolia* are given below

Botanical name: *Commelina ensifolia;*
Family: Commelinaceae;
Kingdome: Plantae;
Class: Angiosperms;
Order: Commelinales;
Genus: Commelina;
Species: C. ensifolia;
Tamil name: Kanavazhar.

Preparation of Extract

A crude extract of *Commelina ensifolia* leaves was prepared by using soxhlet extraction process. About 50g of dried powdered leaf of *Commelina ensifolia* were uniformly packed into the thimble and extracted by using 1000ml of double distilled water to get 5% extract of the inhibitor. The method of extraction process was continued for a day or upto the solvent present siphon tube of an extracting sample getting colorless. Since the extract was captured in a beaker and kept overnight for cooling. The cooled extract was stored for the use of corrosion studies.

Preparation of the specimens

Mild steel specimen (0.026%-S, 0.06%-P, 0.4%-Mn, 0.11%-C and the remaining iron) of the dimensions 1x5x0.2 cm were polished to mirror finish they are

degreased with acetone by using cotton and used for the weight loss studies

Table 1: Preliminary phytochemical screening of aqueous leaf extract of *Commelina ensifolia* [9]

Constituents	Test	*Commelina ensifolia* leaves aqueous extract
Flavonoids	NaOH test	+
Carbohydrate	Molisch test	+
Protein and amino acid	Xanthoprotein test	+
Phenols	Ferric chloride test	+
PhytoSterols	Salkowski's test	+
Tannins	Gelatin test	+
Saponins	Foam test	+
Fixed oils and fats	Saponification test	+

RESULTS AND DISCUSSION

It is well known fact that research activities directing to the improvement of corrosion inhibitors banded on natural products have enormous scope in most of the industries, due to their non-toxic, decomposable nature and are also easily available. Investigation of natural inhibitors is particularly interesting because they are non-expensive, eco-friendly and possess no threat to the surroundings.

In the present investigation, inhibition effect of *Commelina ensifolia* leaves extract in 1.0 M H_2SO_4 solution has been investigated by using weight loss technique. The efficiency of an extract as a corrosion inhibitor can be assigned to the number of mobile electron pairs present, free electrons from π-orbital and the electron density around the hereto atoms .The metal surface adsorbed the extract by applying when mild steel is soaked in the acid solution the phyto-constituents floats from the bulk of solution around the surface of the metal. The highest inhibition efficiency was determined to be 93.38%. Increasing the concentration of *Commelina ensifolia* decreases the corrosion probably due to the adsorption of the inhibitor on the mild steel surface. The inhibition efficiency percentage increases with increase in the concentration of inhibitor. The corrosion inhibition by leaves extract of *Commelina ensifolia* is assigned to the adsorption of the additives on the metal surface. The readings are obtained from the free adsorption method suggests that set of physisorption and chemisorptions valuated for the surface of mild steel. The extract of *Commelina ensifolia* leaves controls the corrosion, due to the presence of the phytochemical constituents are deviating the corroded metal surface into the noble.

Weight loss method

Table-2 give the inhibitive effect of various concentrations of *Commelina ensifolia* leaves extract in 1.0M H_2SO_4 solution. The efficiency of inhibition depends upon the character and manner of adsorption of the mild steel surface. The adsorption is expected to be a quasi-sustitution methods between any of the natural constituents present in the green inhibitor and the water molecules on the surface [10-12]. It is noted that the inhibitor concentration increases the effect of inhibition on mild steel.

Inhibition efficiency (%) = W_0-W_i/W_0×100

Where, W_0= Weight loss in plain acid; W_i= Weight loss in presence of inhibition

Table 2: Inhibition action on mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia*

Volume of Inhibitor(ml)	Rate of corrosion, g cm^{-2} hr^{-1}	Inhibition Efficiency (%)
1	0.0010	17.07
2	0.0008	26.72
3	0.0008	31.54
4	0.0007	39.94
5	0.0006	44.21
6	0.0005	51.92
7	0.0004	62.80
8	0.0003	72.70
9	0.0001	84.98
10	0.00008	93.38

Adsorption isotherm

Adsorption isotherms are actually used to explain the adsorption process. The most commonly used isotherms include Langmuir, Flory-Huggins, Temkin, Frumkin and the currently developed isotherm model of El-Awady et al [13-17]. The endowment of adsorption isotherms explains the adsorption of inhibitor can produce major idea to the nature of the inhibitor-metal interaction. Adsorption of phyto-components occurs as the energy of interaction between molecules and surface of metal is greater than the interaction energy between the water molecules and the surface of metal.

Langmuir adsorption isotherm

Adsorption isotherms are most important to describe the action of mechanism of phyto-electrochemical reaction. Langmuir adsorption isotherm is

$$\Theta = K_{ads}.C/1+k_{ads}.C$$

$$\Theta (1+k_{ads}.C) = K_{ads}.C$$

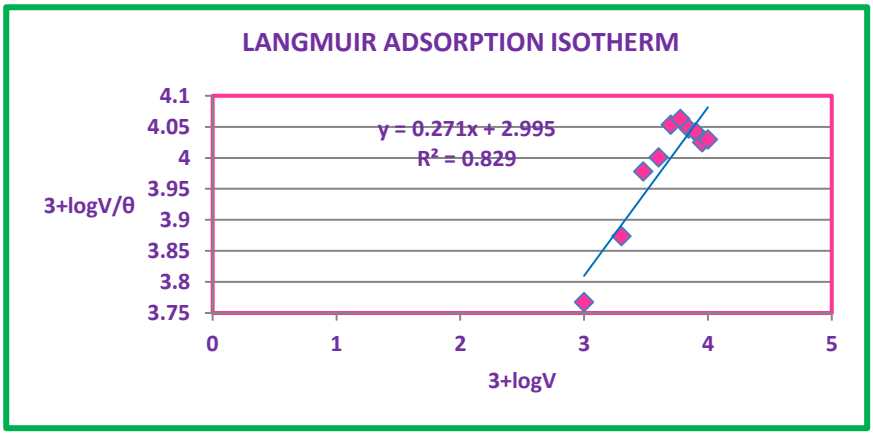
$$\Theta = K_{ads}.C - K_{ads}.C\Theta$$

$$\Theta = (1-\Theta) K_{ads}.C$$

$$\Theta/1-\Theta = K_{ads}.C$$

The plot of 3+log (Θ/1-Θ) against 3+logC is a straight line shown in the below figure-2. Hence the Langmuir isotherm is effective for the process of inhibition.

Figure 2: Langmuir adsorption isotherm for the inhibition action on mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia*



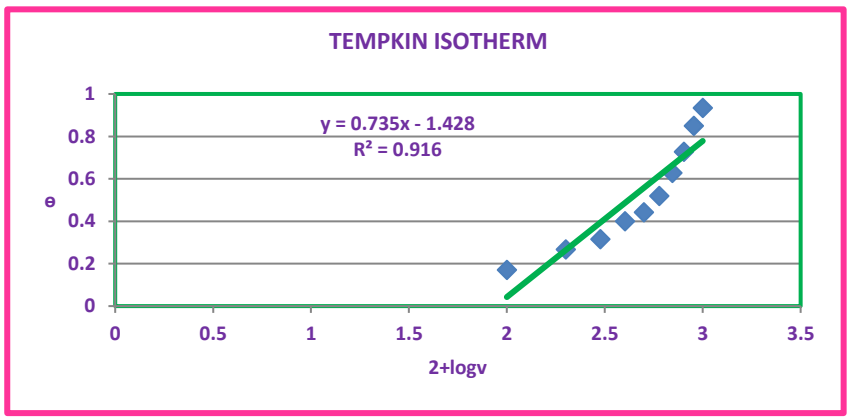
Tempkin adsorption isotherm

It is given by the expression;

Θ = -2.303 log K/2a-2.303 log C/2a

Where "K" represents the adsorption equilibrium constant, "a" represents interaction parameter. The plot of Θ against log C is shown below figure-3. The linear plot indicates that Tempkin adsorption isotherm was obeyed and negative, value of "a" indicated the refusal existing in adsorption layer.

Figure 3: Tempkin adsorption isotherm for the inhibition action on mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia.*



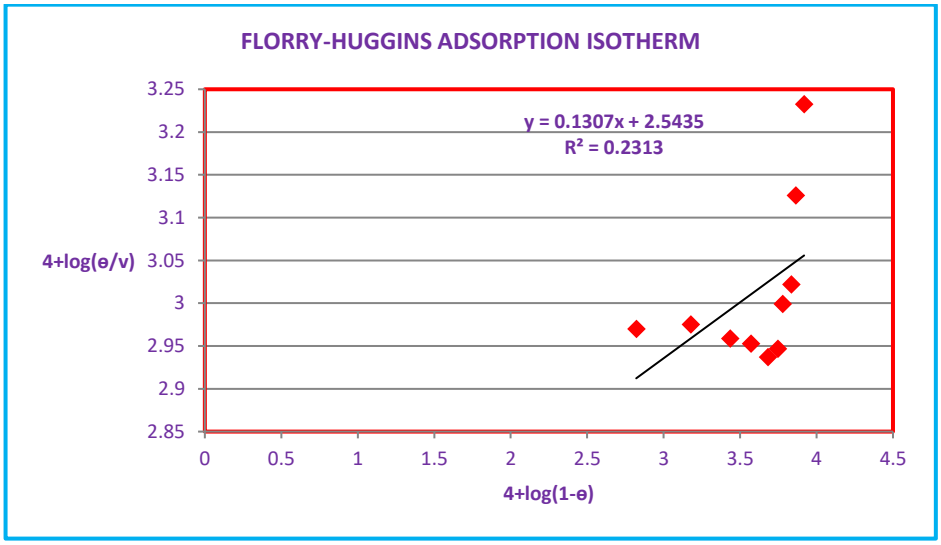
florry-Huggins adsorption isotherm

It is given by the expression

log Θ/C = log K+ x log (1-Θ)

Where 'x' represents the size parameter, and it is a determination of the amount of adsorbed molecules of water replaced by a molecule of inhibitor. The plot of log Θ/C against log (1-Θ) is linear. It is shown in the figure-4. It is indicating that Florry-Huggins isotherm was obeyed.

Figure 4: Florry-Huggins adsorption isotherm for the inhibition action on mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia*



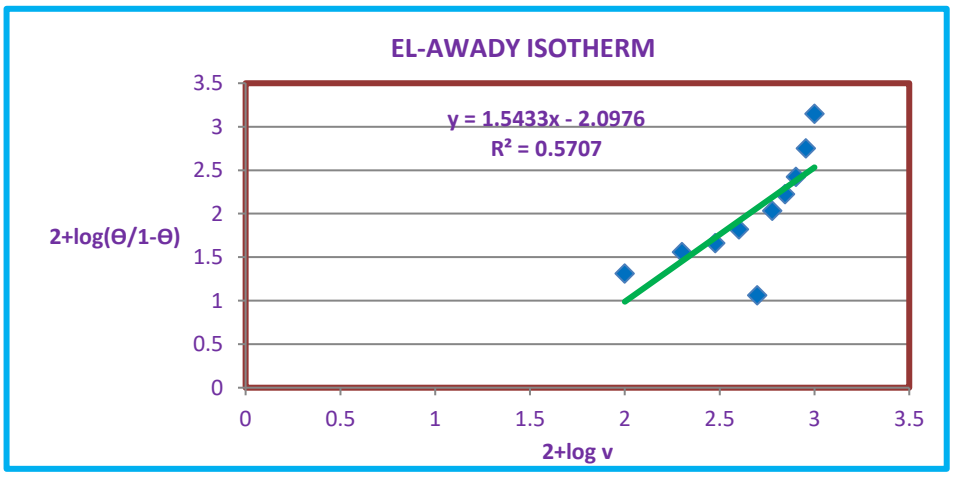
El-awady isotherm

It is given by the expression:

log (Θ/1-Θ) = logK + ylogC

Here K_{ads} is the term of equilibrium constant for adsorption process was determined by the relationship, K_{ads} = 1/k. A plot of 2+log (1-Θ) Vs. 2+ logC is linear .it is shown in figure-5. The value of 1/y is more than one exhibiting that the inhibitor employs to higher than one active spot on the surface of metal.

Figure 5: El-awady adsorption isotherm for the inhibition action on mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia.*



Frumkin isotherm

$K_{ads} V = (Θ/1-Θ) e^{-2aΘ}$

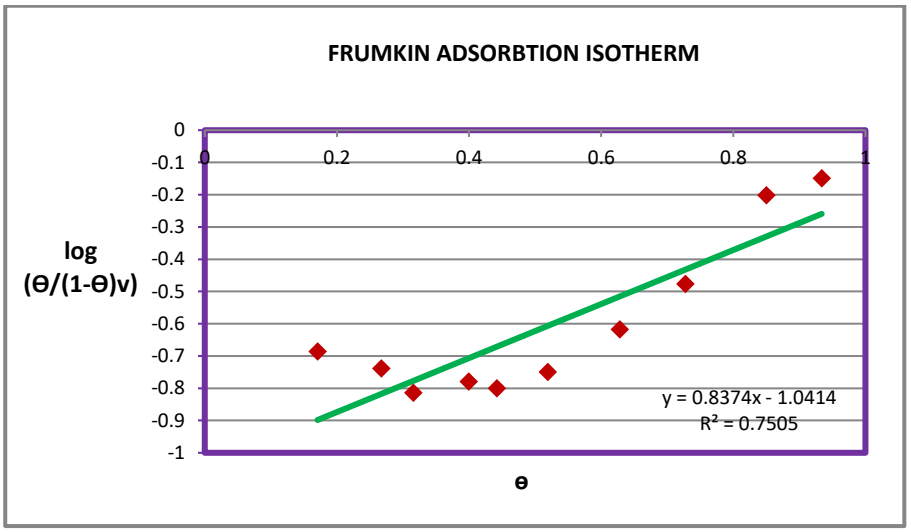
Take logarithm on both sides on the equation, it can be rearranged as given below.

$\log K_{ads}+2aΘ = \log (Θ/(1-Θ)1/v)$

Where, K_{ads} is the adsorption equilibrium constant, V is the inhibitor volume and the interaction parameter describing the lateral interaction among inhibitor

molecular in the adsorbed layer on the metal surface. Linear plot of log (Θ / (1-Θ)1/V) Vs. Θ is shown in Figure-6.

Figure 6: Frumkin adsorption isotherm for the inhibition action on mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia*



Free energy change

The change of free energy for the adsorption (ΔG^0_{ads}) of inhibitor on the surface of mild steel is relevant to the constant of the adsorption based on the equation.

$\Delta G^0_{ads} = -2.303RT\log (K_{ads} \times 55.5)$

From the results, it is noticed that the values of ΔG^0_{ads} were negative and were less than the -40kJ/mole mentioning that the adsorption of leaves extract of *Commelina ensifolia* on the surface of mild steel is spontaneous and consistent with the mechanism action of physisorption is feasible [18-23]. The adsorption parameters are given in Table-3.

table 3: Adsorption isotherm parameters for the inhibition action of mild steel corrosion in 1.0 M H_2SO_4 by leaf extract of *Commelina ensifolia*

Isotherm	$-\Delta G^0_{ads}$	Slope	R^2	a	1/y
Langmuir	7.379	0.271	0.829	-	3.6900
Tempkin	9.252	0.735	0.916	-1.5667	1.3605
Flory-Huggins	7.793	0.130	0.231	-	-7.6923
El-awady	8.280	1.543	0.570	-	0.6480
Frumkin	10.051	0.837	0.7505	-1.3757	1.1947

Comparison of the regression coefficient, R^2 value is highest for Tempkin adsorption mechanism. It indicates that the inhibitor follows Tempkin adsorption isotherm closely than the other isotherm. The negative a value represents that the repulsion exists in the adsorbed molecule layer on the metal surface.

SUMMARY AND CONCLUSION

The inhibitive action of leaf extract of *Commelina ensifolia* on the mild steel corrosion in 1.0 M H_2SO_4 medium was investigated by mass loss method and various adsorption isotherm. When increasing the addition of leaf extract of *Commelina ensifolia* is decreasing the corrosion on mild steel, possibly due to the strong adsorption of the inhibitor on the mild steel surface. The maximum efficiency of inhibition was found to be 93.38%. The mild steel corrosion in 1.0 M H_2SO_4 solution is inhibited by the addition of *Commelina ensifolia* leaves extract.

- The percentage of inhibition efficiency increases with increase in the inhibitor concentration.

- The corrosion on mild steel inhibited by leaves extract of *Commelina ensifolia* is attributed to the adsorption of phytochemical constituents present in the inhibitor on the mild steel surface.
- The values obtained from the weight loss method for the studied inhibitor is appropriating into the Tempkin adsorption isotherm for 1.0 M H_2SO_4. The free energy values of the process of adsorption indicate that the adsorption of the inhibitor on the surface of mild steel exists spontaneously and the mechanism action of physisorption is feasible.
- The leaf of *Commelina ensifolia* protect the corrosion on mild steel because of the phytochemical constituents present in the inhibitor converting the corrosion into the noble.
- The observed results are suggests that the leaf extract of *Commelina ensifolia* is an excellent corrosion inhibitor for the mild steel in 1.0 M H_2SO_4 solution and it can be preferably used to replace toxic, non-decomposable and non-biodegradable inhibitor.

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