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Effect of Leptadenia Hastata (Yadiya) Leaves Extracts on Corrosion Inhibition of Mild Steel Pipe in Acidic Media

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Abstract: *Corrosion inhibition of low carbon steel in 1M HC1 & H_2SO4 in the absence and presence of leptadenia leaves extract at temperature range of 313k-333k was studied using the weight loss, and thermodynamic technique. The extract acts as an inhibitor in the acidic environment. The inhibition efficiency increased with increase in inhibitor concentrations but decreased with increase in temperature. The inhibiting effect could be attributed to the presence of some phytochemical constituents in the leptadenia extract which is adsorbed on the surface of the low carbon steel and the inhibition efficiency for leaves in both media are greater 70%, therefore, it serves as good inhibitors. Thermodynamic parameters reveal that the adsorption process is spontaneous and also obeyed Langmuir Adsorption Isotherm.*

Key words: *Corrosion; Leptadenia hastata; Low carbon steel and inhibition*

1.0 INTRODUCTION

1.1 Background of Study

Studies on preventing the corrosion of steel in acidic environments and the problematic chemical processes that arise have attracted the attention of researchers from a wide range of industrial sectors (Rani et al., 2012). Corrosion is a common problem for steel and directly impacts its cost and safety. The corrosion of iron can cause structural damage and lead to changes in the mechanical and chemical properties of plants, vessels, pipes and other processing equipment. These effects demonstrate that corrosion would produce considerable costs if an effective solution is not identified from its study and research. Preventing the corrosion of steel has played an important role in various industries, especially in the chemical and petrochemical processing industries that employ the use of steel. Corrosion of metals however is considered to be serious problem in most industries, often corrosion processes are electrochemical in nature and accompany by chemical change that can compromise materials reliability. It is critical particularly in view of the reliability is not assured, safety is compromised and failure (Revie, and Uhlig, 2008). Corrosion causes gradual decay and deterioration of iron and their alloys when exposed to the action of fluid in industrial processes, chloride, sulphate and sulfur containing ions poses a complex problem both internally and externally, among various method of combating corrosion. The use of inhibitors is one of the best and widely used methods for steels in the oil and gas industry and proven to be successful (Ebenso, 2011). Acid solutions are commonly used for the removal of undesirable scale and corroded parts in the metal working, cleaning of boilers and heat exchangers. Hydrochloric acids are most widely used for all these purposes. However, over-pickling of metal leads to a rough, blistered coating. Carbon steel is among the most widely used engineering materials such as metal-processing equipment, marine applications, nuclear and fossil power plants, transportation chemical processing, pipelines, mining and construction. Iron and its alloy as construction materials in industrial sectors has become a great challenge for corrosion engineers or scientists nowadays (El-Kacimi.,2016). Corrosion inhibitor is a chemical compound that, when added to a liquid or gas, decreases the corrosion rates of a material., typically a metal or an alloy. The effectiveness of corrosion inhibitors depends largely on fluid composition, quantity of water and flow regime (Abdel-Gaber etal.,2011). Most recently, the practice of corrosion inhibition is greatly influenced by legislation developed as a result of hazardous effects such as the environment degradation and pollution arises from the use of some chemical inhibitors (Sangeetha et al, 2011). The injection of film-forming corrosion inhibitors is a common practice to protect carbon steel against internal and external corrosion bio-extracts have prominent use for corrosion inhibitors, thereby the trend in replacing some common hazards inhibitors with inhibiting action of bio-extracts to form a protective barrier between the steel surface and the corrosive species in the fluids, irrespective of the corrosive environment (Amitha et al., 2012).Leptadenia hastata (Asclepiadaceae)is commonly known in some West African countries because of its various applications. For instance, the leaf extract from Leptadenia hastata has been used to Onchocerciasis in Mali (Togola et al., 2008); scabies in Chad (Betti et al., 2011); hypertension, catarrh and skin diseases in Nigeria (Dambatta and Aliyu, 2011). Despite the great number of studies devoted to the subject of corrosion inhibitors most of what is known, is as a result of trial and error, both in the laboratory and the fields. Historically, the development of corrosion inhibitors has always been determined by their effectiveness, and they were often based on ecologically problematic heavy metals. The development of new corrosion inhibitors of non-toxic type, which do not contain heavy metals and inorganic phosphates, is of considerable importance (Fengling, 2009). Therefore, there is need for the current study to assess the inhibitory effect of leptadenia hastata leaves on the mechanical and corrosion behaviour of low carbon steel in acidic environments on corrosion inhibition.

1.3 Chemistry of Corrosion

Common structural metals are obtained from their ores or naturally-occurring compounds by the expenditure of large amounts of energy. These metals can therefore be regarded as being in a metastable state and will tend to lose their energy by reverting to compounds more or less similar to their original states. Since most metallic compounds, and especially corrosion products, have little mechanical strength a severely corroded piece of metal is quite useless for its original purpose. Virtually all corrosion reactions are electrochemical in nature, at anodic sites on the surface the iron goes into solution as ferrous ions, this constituting the anodic reaction. As iron atoms undergo oxidation to ions they release electrons whose negative charge would quickly build up in the metal and prevent further anodic reaction or corrosion. Thus, this dissolution will only continue if the electrons released can pass to a site on the metal surface where a cathodic reaction is possible. At a cathodic site the electrons react with some reducible component of the electrolyte and are themselves removed from the metal. The rates of the anodic and cathodic reactions must be equivalent according to Faraday's Laws, being determined by the total flow of electrons from anodes to cathodes which is called the "corrosion current", Icor. Since the corrosion current must also flow through the electrolyte by ionic conduction the conductivity of the electrolyte will influence the way in which corrosion cells operate. The corroding piece of metal is described as a "mixed electrode" since simultaneous anodic and cathodic reactions are proceeding on its surface. The mixed electrode is a complete electrochemical cell on one metal surface.

The most common and important electrochemical reactions in the corrosion of iron are the Anodic Reaction (Bill., 2003)

$$Fe \rightarrow Fe^{2+} + 2e^{\sim} \quad 1$$

$$2H^{+} + 2e \text{ -*} H_2 \quad 2$$

$$H_20 + {}^{1}/_{2}\, 0_2 + 2e \text{ -»} 20H^{\sim} \quad 3$$

Reaction 2 is most common in acids and in the pH range 6.5 - 8.5 the most important reaction is oxygen reduction 3 In this latter case corrosion is usually accompanied by the formation of solid corrosion debris from the reaction between the anodic and cathodic products (Bill and Gareth, 2003).

$Fe^{2+} + 20H^{\sim} \rightarrow Fe(OH\}_{2>}$ Iron (II) hydroxides 4

Pure iron (II) hydroxide is white but the material initially produced by corrosion is normally a Greenish colour due to partial oxidation in air.

$2Fe(OH)_2 + H_20 + {}^1/_2\ 0_2$ -» $2Fe(OH)_3$, Hydrated Iron (III) oxide 5

$e + 3H_20 \rightarrow Fe_20_2 + 6H^+ + 6e$ 6

2.0 MATERIALS AND METHODS

2.1 Experimental Site Description

Field experiment was conducted at the Ramat Polytechnic, Maiduguri, in the Sudano-Sahelian region of northern Nigeria. The site lies between latitude 11^05 N and longitude 13^009E (Kyari *et al*., 2014).

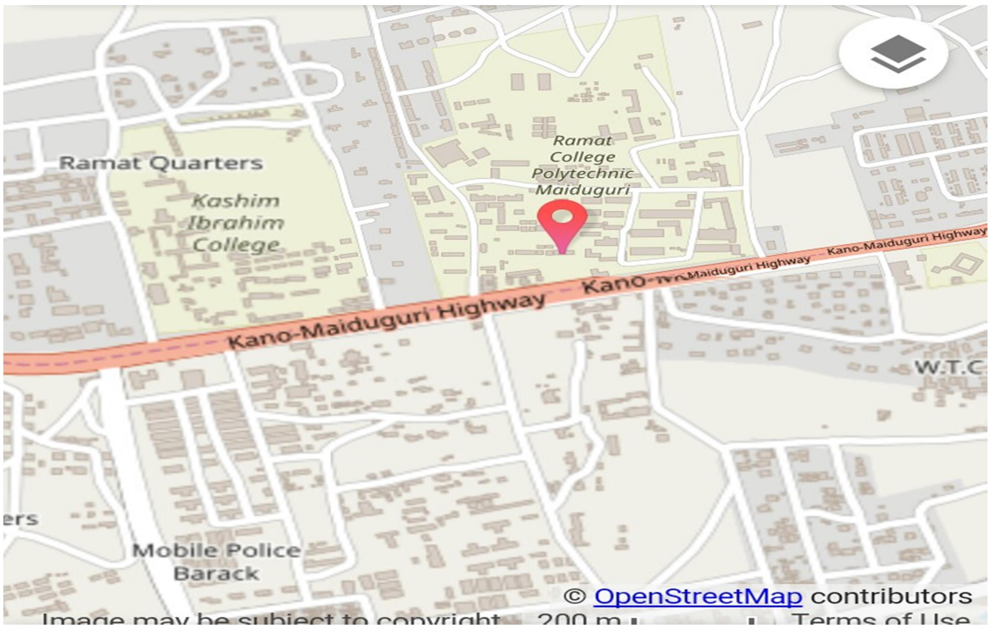

Fig: 1 Map of the study site.

2.3 Materials and Equipment used for the study

The Leptadenia hastata plant was collected from a garden in the Ramat polytechnic Maiduguri, Borno State, authenticated by a plant taxonomist, of the Polytechnic. The leaves were harvested, washed and shade dried for a period of two weeks and then ground to powder using a mortar and pestle. The powder was sieved to obtain the fine powder, it was then labeled and stored for use. Extraction of Plant Material Maceration technique as described by (Azwanida *et al* 2013) was used for extraction in the current study. However, the phytochemical chemical and gravimetric tests were carried out on the leaves extract to identify the presence of various chemical constituents These tests were carried out in the Science Laboratory and Technology Department of the Ramat polytechnic, Maiduguri. However, the reagents and chemicals All the reagents used for the research were of analytical grades and obtained from the Department of Science Laboratory Technology Chemistry lab of the Polytechnic. They include low carbon steel, distilled water, dichloromethane, ethyl acetate, n-butanol, silica gel, methanol, and normal saline. Apparatus and equipment These include: percolator, milling machine, rotary evaporator, glass bottles, glass column, glass wool, GC-MS spectrometer, micro-hematocrit centrifuge, water bath, Whitman filter paper, measuring cylinders, hand gloves, masking tape, beakers, syringes, spatula, and weighing balance.

2.4 Metal Composition Analysis

Determination of the metal

composition was accomplished by the used of the precise chemical composition and alloy grade of metal are essential in many industries and also the response of in-service of a material is a function of its elemental composition, mechanical and thermal history. The material (low carbon steel) was subjected for elemental analysis.

2.5 Sample Preparation

Section of the specimen was cut for elemental analysis using Emission optical spectrometer. However, the steel material in the form of a pipe was sectioned by turning in the lathe and mechanically pressed into straight square rod, which was further turned into cylindrical cross for further processing. Sample for tensile, hardness and impact test using Universal testing machine, Rockwell testing machine and Hounsfield balance impact testing machine respectively based on each machine specification was prepared

3.0 RESULTS AND DISCUSSION

As illustrated from Table 1. The However, carbon steel (containing <1.7% C in an iron matrix) are used as low cost, large volume construction materials in chemical, petrochemical, and power plants, as well as in process vessels, tubing and other load supporting structures. Manganese, chromium, Nickel and copper are responsible for strength and corrosion resistant which are present in low carbon steel used for this research in appropriate proportion. For more details, see figure 1.

Table 1: Elemental Analysis

% Element Composition							
C	Si	M.	P	S	Cr	Mo	Ni
0.212	0.256	0.404	0.0222	0.0092	0.207	0.0022	0.0393
Al	Co	Cu	V	Sn	As	Ca	Sb
0.0077	0.0015	0.0123	0.0031	0,0033	0.0045	0.0031	0.002
Se	Zn	N	Fe				
0.0186	0.0017	0.0135	98.7768				

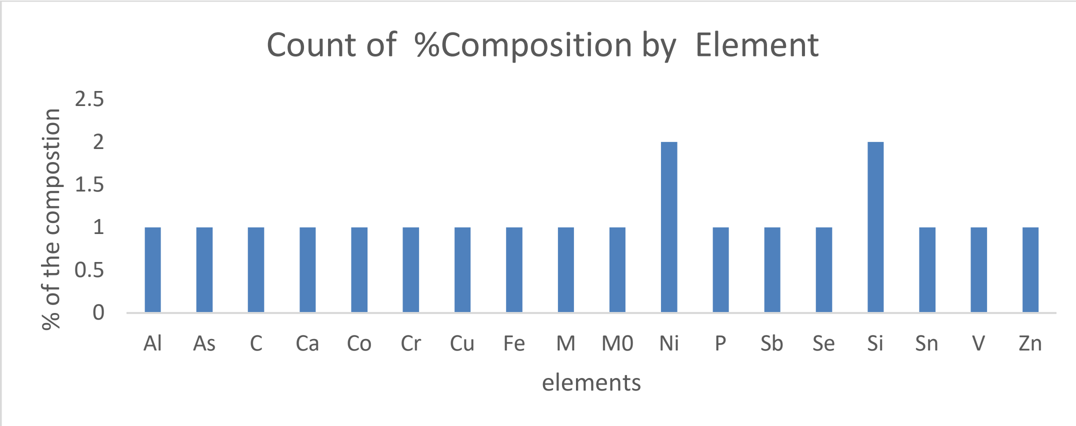

Figure 1: Elemental Analysis

3.1 Phytochemical and Physicochemical Analysis

The experimental result obtained on Phytochemical and Physicochemical Analysis was presented in Table 2. The phytochemical result showed that the leaves contained higher percentage of saponins, tanins and alkaloids as compared to the leaves which makes the peel better for corrosion inhibition due to the presence of flavonoids monomers (tannins) that can easily be adsorbed on the surface of the metal. Similarly, Flavanoids and phenols are high in leaves extracts and these constituents contains O, N atoms which are the centre of adsorption. The leptadenia extracts established their inhibitive actions through adsorption of phytochemical components molecules on the metal surface. The plant extract was found to contain heterocyclic compounds, heteroatoms and multiple bonding within the chemical structure of their bulk organic compounds in form of constituents can form chellates with iron as similarly reported by (Yahya *et al.,*2008).

Table 2.: Phytochemical screening of leptadenia leaves

S/No.	Constituents	Tests	Leaf
1	Carbohydrates	Molish test	+
2	Anthroquinons	Bontrager test	-
3	Cardiac glycosides	Kelle-Killiani test	+
4	Saponins	Frothing test	2.5%
5	Steroids	Lieberman Buchard test	+
6	Triterpenes	Lieberman Buchard test	+
7	Tanins	Ferric chloride test	5.2%

8	Flavanoids	Shinods test	9.7%
9	Alkaloids	Drangendoff test	2.6%
10	Phenols	Pyridine ferric test	7.8%

Similarly, as shown in Table 3, the various presence, absence and the percentages of phytochemical constituents of the leaves possessing the higher concentration in saponins, tanins and alkaloids except for flavanoids and phenols with leaves' posessing higher percentages of concentrations. Usually, the leptadenia leaves contains fibre which helps in reducing the corrosion and also due to the presence of low molecular mass constituents such as amino acids, organic acids, sugars, phenolics, and other secondary metabolites comprise the majority of root secretions through the leaves as posited by Eddy et al. (2008).

Table 3: Quantitative Phytochemical Analysis

S/N	Phytochemical Constituents	Composition of Leaves
1	Alkaloids	65mg/g
2	Flavanoids	59mg/g
3	Saponins	54mg/g
4	Tanins	56mg/g
5	Phenols	15mg/g

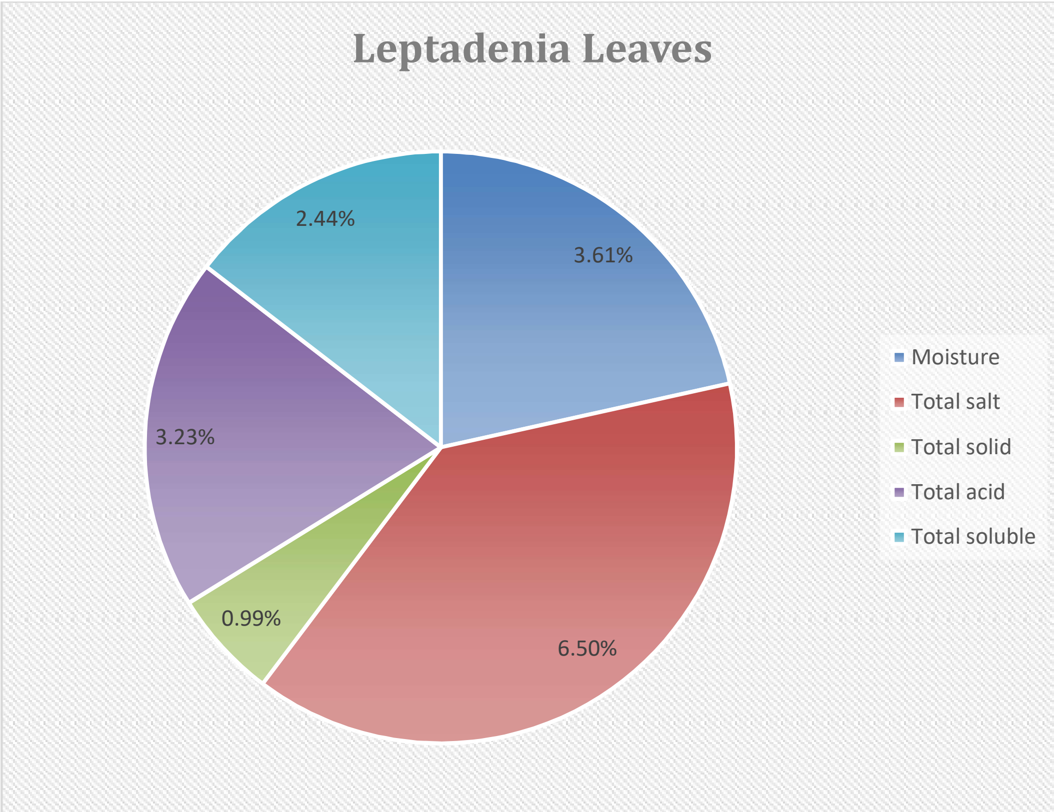

Figure 2: Physicochemical analysis

3.2 Thermodynamic **parameters of Corrosion in HC1**

The experimental results on kinetic parameters of the corrosion of low carbon steel HC1 were shown in Table 4 and 5 below

Table 4: Thermodynamic parameter of the corrosion of low carbon steel in 1m HCl from 0 -1000ppm of extracts of leptadenia extracts

Concentration (ppm)	Activation Energy (E) (KJmor¹)	Regression coefficient, R	AH (KJmol"	AS (Jmol^K"	Regression Coefficient R^2
Leaves					
0	31.36876	0.9856	31.36876	-126.197	0,9856
250	25.17083	0.957	25.17083	-145.49	0.9570
500	30.68138	0.9785	30.68138	-131.767	0.9785

750	62.72986	0.9835	62.72986	-31.7498	0.9835
1000	52,04959	0.9681	49.36516	-53.3363	0.9649

As presented in Table 4: The activation energies in the presence of different concentrations of inhibitors 1m HC1 is higher than in the absence of inhibitors. The decrease in inhibition efficiencies with increasing temperature and increase in activation energy in the presence of inhibitors indicates the adsorption is physical adsorption. The positive sign of enthalpies of activation reflect the endothermic nature of dissolution process of low carbon steel in acidic medium. The activation energy (E_a) values shown in Table 5: also indicates the inhibitive extracts of potato are capable of inhibiting corrosion at higher temperature due to the increase in activation energy as the inhibitor concentration increases which suggest the formation of energy barrier of corrosion reaction in form of a physical barrier adsorbed inhibitor molecules complex as too close to the citation of Vermaa et al., (2016).

Table 5: Thermodynamic parameter of the corrosion of low carbon steel in lm H2SO4 from 0 –l000 ppm extracts of leptadenia extracts

Concentration (ppm)	Activation Energy (E) (KJmor^1)	Regression coefficient, R^2	AH (KJmor^1)	AS (Jmor'K"')	Regression Coefficient R^2
Leaves					
0	36.13257	0.9916	36.13257	-91.9139	0.9916
250	52.65272	0.9909	49.97021	-53.3363	0.9649
500	57.654098	0.9726	57.654098	-61.5236	0.9726
750	90.716054	0.9312	90.1411	72.23729	0.9317
1000	80.0321	0.9281	80.0321	69.324	0.9281

3.3 CONCLUSION AND RECOMMENDATIONS

The research work has shown the analysis of the inhibitory effects of leptadenia leaves on the mechanical and corrosion behaviour of low carbon steel in acidic environments. From the results, the following conclusions are made:

(i)The leptadenia leaves are phyto-toxic free as it contains more of salts than the acids with greater percentages of phytochemical and physicochemical screening. However, the phytochemical and physicochemical screening of the extracts showed that the leaves contains carbohydrates, glycosides, cardiac glycosides, saponins, tanins, flavonoids, Alkaloids, steroids and triterpenes which are active inhibiting components having a combined effect towards the corrosion inhibition of low carbon steel in acidic media. In gravimetric measurement, the inhibitory effect of the extracts of leptadenia leaves' shows that the leaves inhibit corrosion higher than that of the in HC1 with both obtaining optimum performance at the higher concentrations and the inhibitive corrosion effect of the leptadenia extracts are fairly low in H2SO4 as compared to HC1. However, the efficiency of inhibition of the leaves are high in HC1 and average inhibitive corrosion in H2SO4 .

(ii) In thermo- gravimetric measurement, the inhibition efficiency of the extracts increases with increasing temperature and concentration in HC1 medium and considerably a converse effect in exhibiting a significant effect in increasing inhibition with concentration.

(iii) Corrosion reduces the mechanical properties of low carbon steel at room and elevated temperature but addition of inhibitors improves upon it considerably and the scanning electron microscope analysis (SEM) shows that the addition of inhibitor reduces the corrosion of low carbon steel when exposed of HC1 and H2SO4.

4.2 Recommendations

(i)Since this experiment is limited to low carbon steel further studies over different carbon properties on same leaves extract or else are required in order to develop reliable values.

(ii) Further research need to be carried out at different element composition and method

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