



ORIGINAL RESEARCH ARTICLE

EFFECT OF LANTANA CAMARA, CASSIA OCCIDENTALIS AND RUCINUS COMMUNIS SEEDS AND LEAVES EXTRACT AS CORROSION INHIBITORS OF MILD STEEL IN 2M HCL SOLUTION

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ABSTRACT

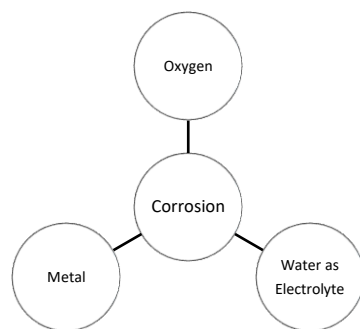
Corrosion phenomena, control, and prevention are significant scientific issues that require ongoing attention due to the increasing demand for metallic materials in various technological developments. The use of natural inhibitors is an attractive option for preventing corrosion due to their environmental friendliness, cost-effectiveness, and ease of sourcing and renewability. This research investigates the potential of locally sourced, non-edible plants as corrosion inhibitors. Specifically, extracts from *Lantana camara*, *Cassia occidentalis*, and *Ricinus communis* seeds and leaves were tested on mild steel in a 2M HCl solution to determine their corrosion prevention potency and compare the inhibitive properties between the leaves and seeds of each plant. The maceration method was employed for extraction using ethanol as the solvent. Corrosion tests were conducted using the weight loss technique to determine the corrosion rate of mild steel coupons over a 14-day period, with measurements taken at 24-hour intervals. The results indicate that *Cassia occidentalis* leaves and *Lantana camara* leaves exhibit lower corrosion rates compared to their respective seeds. Conversely, *Ricinus communis* seeds showed a lower corrosion rate than its leaf extract. All inhibitors demonstrated notable inhibitive properties, with *Cassia occidentalis* leaves displaying the highest inhibitive efficiency, likely due to its high phytochemical constituents.

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1.0 Introduction

Mild steel also known as plain-carbon steel, is the most common form of steel because its price is relatively low, while it provides wide range of applications because of its material properties. However, mild steel has a great challenge of low corrosion resistance especially in acidic environments (Marko et al., 2016). Corrosion phenomena, control, and prevention are significant scientific issues that require ongoing attention due to the increasing demand for metallic materials in various technological developments (Loto et al. 2011). Corrosion can be defined as a disparaging phenomenon, chemical or electrochemical, which can attack metal or alloy through reaction by the surrounding environment (presence of oxygen, water, and other chemicals).and in extreme case may cause structural failure (Aji et al.2016). The effects of corrosion on the safe, reliable and efficient operation of equipment or structures are often more serious than simple loss of a mass of a metal. Failures of various kinds and the need for expensive replacements may occur even though the amount of metal destroyed is quite small (umoren, 2009).

Corrosion can occur also in other materials other than metals, materials such as ceramics, wood or polymers, although the corrosion rate in metals is very high. Corrosion it's a continuous process, often difficult to eliminate totally, it can only be slowed down, corrosion prevention is achievable than complete elimination.



**Figure 1:** Requirements for the atmospheric corrosion reaction

Most of the corrosion inhibitors are synthetic chemicals, expensive and very hazardous to the environment. Therefore, it is desirable to source for environmentally safe inhibitors (Paul et al. 2012). Owing to the increasing ecological awareness as well as the strict environmental regulations, and consequently the need to develop environmentally friendly processes, attention is currently focused on the development of green alternatives to mitigating corrosion. Due to the availability of these plants and the simplicity in processing them into inhibitors, these plants extracts are less expensive when compared to inhibitors produced using synthetic chemicals.

Mshelia et al. (2017) used gravimetric technique to compares the corrosion inhibition efficiency of an abundant and eco-friendly plant extracts of *Azadirachta Indica* (Neem) and *Jatropha curcas* in acidic media (2M  $H_2SO_4$  solution) using mild steel. The results obtained show that all the plants under study are good corrosion inhibitors, among which leaves extract of Neem as the most effective. Phytochemical analysis shows that the constituent of the ethanol extracts of Neem and *Jatropha curcas* contains cardiac glycosides, saponins and tannins, while flavonoids were found in *Jatropha curcas* leave extract alone. Sivaraju et al, (2010) also investigated the inhibition effect of *Acalypha indica* extract on mild steel corrosion in 1M phosphoric acid using Weight loss and polarization techniques at a temperature of 30°C and 60°C respectively. The results showed that inhibition efficiency increased with increase in concentration of the plant extract and also the corrosion rate increased with increase in temperature and decreased with increase in concentration of inhibitor. Furthermore, Loto et al. (2014) reported the effect of *Manihot Esculenta C* (cassava) Leaf Extract Additive on the Zinc Electroplating on Mild Steel in Acid Chloride Solution. The corrosion resistance of the plated surface was determined by gravimetric, potential measurement and corrosion current methods. Also, inhibitor study was conducted by Quraishi et al. (2009) on the inhibition of black pepper extract. The results obtained revealed that Black pepper extract was a good corrosion inhibitor for mild steel in hydrochloric acid medium and maximum inhibition efficiency (98%) was found at 120 ppm at 35 °C. Therefore, this paper presents the result of *Lantana camara*, *Cassia occidentalis* and *Rucus communis*. (Seeds and leaves) extract for corrosion prevention in Mild steel.

## 2. Materials and Method

### 2.1 Materials and Equipment

Some of the materials used includes *Lantana camara*, *Cassia occidentalis*, *Rucus communis* seeds and leaves, and Mild steel sheet coupon. Equipment used were digital analytical weighing mass balance of (0.001) accuracy, drying cabinet, rotary evaporator, measuring cylinder, beakers, wired brush and sand paper, filtration funnels, sieve, mechanical shaker and seven (6) sample containers, which contained the acid solution into which the mild steel was immersed.

### 2.2 Method

This explains the procedure on how the research was carried out.

#### 2.2.1 Preparation of the sample

Fresh leaves and seeds of the *lantana camara*, *Cassia occidentalis* and *Rucus camminis* were collected from the plant within the environs of university of Jos main campus (Bauchi road) Jos, Plateau state for the purpose of this research, in natural condition. The leaves were washed under running tap and were later dried under shade for about 10days. The fruits of *Lantana camara* was mild crushed in order to obtained the seeds, but the seeds of *Cassia occidentalis* and *Rucus camminis* were enclosed in a pod, the pod was braked in order to

obtained the seeds. The dried leaves and seed were then grounded to powder form and 60g weights are placed in different containers each.

### 2.2.2 Extraction

Extraction was conducted using Maceration technique carried out at the Department of Pharmacognosy, Faculty of Pharmacy, University of Jos. 60g of each powder was weighed into containers. 70 % concentration of Ethanol was added to each container containing the powdered samples, the powdered samples were allowed to soak overnight (24hrs) at room temperature (25°C) and was shake very well using mechanical shaker. The seeds powders were allowed to soaked for 5days with frequent agitation as similar work was reported by (Loto 2011).

The content was then filtered using non-absorbent cotton wool on a Bucher funnel; the residue was then subjected to several parts of rinsing and filtration with fresh solvents to attain some level of maceration (extraction). The collective filtrate was evaporated to dryness with the aid of rotary evaporator and a drying cabinet at a controlled temperature not above 70°C. Each of the extracts yield was transferred to a clean bottle and covered properly. Its phytochemical screening and identification of some basic compounds were carried out. Plate 1 shows the drying cabinet at controlled temperature not above 70°C. Plate 2 depict the powder samples being soaked with 70% of Ethanol. Plate 3 indicated the soaked powdered samples on mechanical shaker. Plate 4 shows the evaporation of the filtrate with the aid of Rotary Evaporator. Whereas, Plate 5 indicated the filtration of extracts using non-absorbent Wool.



**Plate 1:** Drying cabinet at controlled temperature not above 70°C



**Plate 2:** Powder samples being soaked with 70% of ethanol



**Plate 3:** Soaked powdered samples on mechanical shaker





**Plate 4:** Evaporation of the filtrate with the aid of rotary evaporator



**Plate 5:** Filtration of extracts using non-absorbent wool

## 2.3 Phytochemical Analysis

Phytochemical analysis of the plant extracts was done at the Faculty of Pharmacy, University of Jos following the standard procedure to determine the presence of Saponins, Alkaloids Tannins, Carbohydrates, Flavonoids, Cardiac glycosides, and Glycosides.

### 2.3.1 Test for alkaloids

About 0.5g of each extract was stirred with 3 ml of 1% aqueous hydrochloric acid on a steam bath, the filtrate was treated with few drops of Mayer's reagent. Precipitation this reagent was taken as preliminary evidence for the presence of alkaloids in the extracts.

### 2.3.2 Test for tannins

About 0.5g of each plant extract was stirred with 1ml of distilled water, filtered and ferric chloride reagent added to the filtrate. A blue-black, green, or blue –green precipitate was taken as the presence of tannins.

### 2.3.3 Test for saponins

About 0.5g of each plant extract was shaken with water in a test tube. Frothing which persist on warming was taken as preliminary evidence for the presence of saponins.

### 2.3.4 Keller Killiani test for cardiac glycoside

100mg of extract was dissolved in glacial acetic acid containing one drop of ferric chloride. 1 ml of concentrated sulphuric acid was added down side. A brown ring colour was formed at interphase indicated the presence of a deoxysugar characteristics of cardenolides.

### 2.3.5 Test for anthraquinones

Borntragers test was used for the detection of anthraquinones 0.5g of each extract were taken into a dry test tube and 5ml of chloroform was added and then shaken for about 5 mins. The extract was filtered, the filtrates of the extract shaken with an equal volume of 100% ammonia solution. A pink violet in the ammoniacal lower layer indicates the presence of free anthraquinones.

### 2.3.6 Test for carbohydrates

100mg of each extract was dissolved in 3ml of distilled water and mixed with few drops of molisch reagent, then 1ml of concentration sulphuric acid was carefully added down the side of inclined tube so that the acid forms a layer beneath the aqueous solution without mixing it. A reddish ring at junction of the liquids was observed indicating the presence of carbohydrates.

### 2.3.7 Test for flavonoids

5ml of 20% sodium hydroxide was added to equal volume of the extract. A yellow solution indicates the presence of flavonoids.

### 2.4 Preparation of 2M HCl Solution (test solution)

The experiments were performed in 2 M HCl solution. The acid solution of 2 M HCL was prepared from a standard concentration of hydrochloric acid having percentage purity of about 39% using the relation 1 (Aji et al, 2016) to prepare the 2M HCL.

$$V = \left( \frac{MWT}{\text{Specific gravity}} \right) \left( \frac{100}{36} \right) (2) \quad 1$$

where V = volume, MWT = Molecular Weight

$$V = \left( \frac{36.5}{1.18} \right) \left( \frac{100}{36} \right) \quad 2$$

Thus 2 liters of 2M of HCL, was prepared, the required volume of HCL will be  $V = 171.84 \times 2 = 343.68$  ml

### 2.5 Preparation of Mild Steel Coupon

The sheet of mild steel used for this study was obtained commercially from Building material Bukuru Market in Jos. The Mild steel sheet was mechanically cut into rectangular coupon samples of dimension of (50x30x2) mm. A small hole was drilled near the strip edge of the coupon which a thread will be tied for easy handling. During the study the coupon samples were descaled by wire brushing and polished using abrasive papers (sand paper) of different grades grits to obtained smooth and rust, dirt's free surface and washed with ethanol to remove any form of grease or oxide. They were then cleaned with acetone.

### 2.6 Gravimetric Method

The inhibitive properties of the extracts were evaluated using weight loss method. Weight loss measurement was performed on seven (7) mild steel coupons. The Weighed mild steel coupons were fully immersed in each of the test solution media for 14 days, also another weighed mild steel coupon specimen was immersed in to 2M HCL which does not contain the extract, this served as the control experiment. The test specimens were taken out of the corrosive media after every 24 hours at room temperature and it was followed by washing with distilled water, then after on rinse with acetone and air dried to remove corrosion products, air-dried and re-weighed to measure the weight loss. This process was done every day uninterrupted up to the 14<sup>th</sup> day. From this observed data for 14 days, the corrosion rate Cr (mm/yr), the percentage inhibition efficiency I.E (%), Weight loss  $W_L(g)$  was determined.

### 2.7 Weight loss ( $W_L$ )

The loss in weight of the coupons as the result of corrosion (coupons in the presence of acidic media) was calculated using equation (3).

$$WL(g) = W_i - W_f \quad 3$$

where  $W_i$  and  $W_f$  are initial weight and final weight.

### 2.8 Tests carried out

In the cause of this study several tests were conducted as shown in the sub-sections below.

#### 2.8.1 Corrosion inhibition efficiency

The inhibition efficiency percentage was calculated using equation (4) (Mshelia et al., 2017).

$$\%IE = \frac{R_{blank} - R_{inh}}{R_{blank}} \quad 4$$

### 2.8.2 Corrosion rate

The corrosion rate of the mild steel was calculated from weight loss of the coupons at room temperature and at fixed (constant) concentration (Mshelia et al., 2017).

$$CR = \frac{87.8\Delta W}{\rho AT} \left( \frac{mm}{yr} \right) \quad 5$$

where,  $W$  is the weight loss (g),  $\rho$  is the density in g/cm<sup>3</sup>,  $A$  is the area in cm<sup>2</sup>, and  $T$  is the time of exposure in hours.

### 2.8.3 Surface coverage ( $\theta$ )

The surface coverage ( $\theta$ ) of the mild steel was calculated from the corrosion rate, as a result of adsorption of inhibitor molecules was determined using the equation provided in equation 6.

$$\theta = \frac{R_{blank} - R_{inh}}{R_{blank}} \quad 6$$

## 3. Results and Discussion

The results obtained from the tests and observation made during the experiment are presented.

### 3.1 Phytochemical Analyses

The results obtained from the phytochemical analysis are shown in table I. The phytochemical analyses of the plants (leaves and seeds) extract reveal the presence of alkaloid, saponins, tannins, flavonoids, carbohydrates, anthraquinones, and cardiac glycosides.

**Table I:** Phytochemical constituents of the plant

Chemical Constituents	<i>Lantana Camara</i> Leaves	<i>Lantana Camara</i> Seeds	<i>Rusinus camminis</i> Leaves	<i>Rusinus camminis</i> Seeds	<i>Cassia oxcdentalis</i> Leaves	<i>Cassia oxcdentalis</i> Seeds
Alkaloids	++	+++	+++	+++	+++	+
Saponins	++	-	+	-	-	-
Tannins	+++	++	+++	-	+++	+++
Flavonoids	+++	+++	+++	+	+++	+++
Carbohydrates	++	++	++	+	+	++
Anthraquinones	-	-	-	-	-	+
Cardiac glycosides	+	+++	++	-	+++	+

KEY: - Absent + Present ++ Moderately Present +++ Highly Present

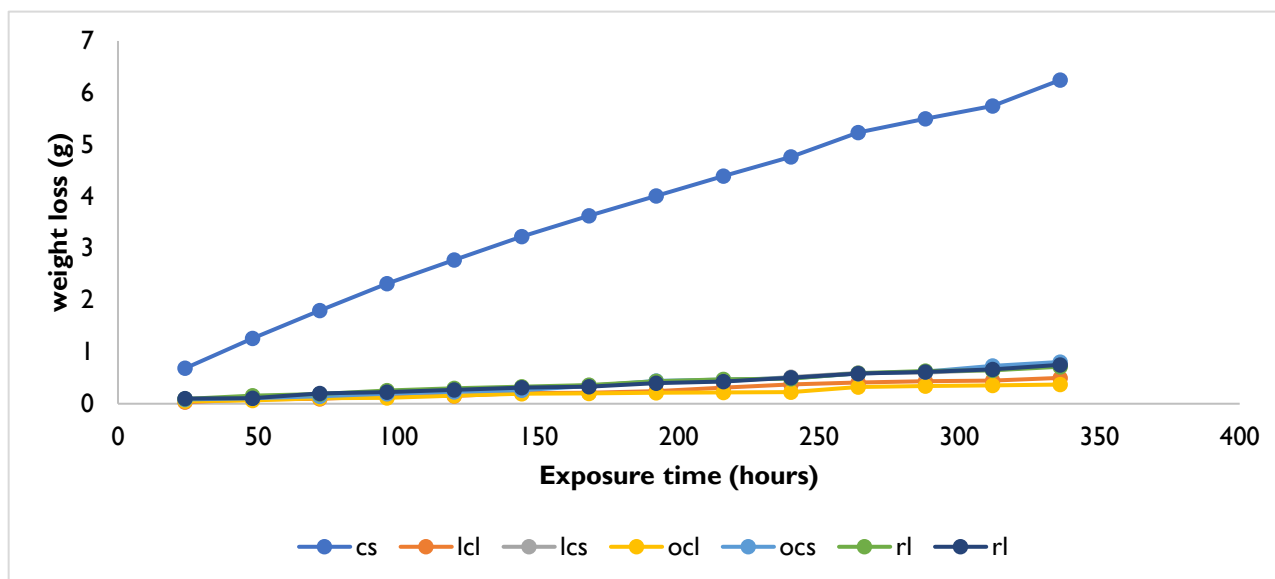
From the results of the phytochemical analysis in Table I alkaloids and flavonoids are present in all the plant (leaves and seeds) extract, generally the natural compounds found in all the plant (leaves and seeds) extracts will form a film on the surface of the mild steel, which will serve as a hurdle at the surface of the mild steel through the mechanism of adsorption, thereby inhibiting the corrosion process of the mild steel coupon. The phytochemical component of plants (leaves and seeds) extract encompasses rich naturally synthesized eco-friendly organic compounds which combat corrosion on mild steel in an aggressive media. According to Iloamae et al. (2013), these compounds contain nitrogen and oxygen which are the center for chemical adsorption on the mild steel.

Alkaloid present in plants extract have a fascinating feature to inhibit corrosion, alkaloid prevent metal corrosion by adsorption of their molecules on metals surface to form a protective layer.

Saponins has rich oxygen molecules that provides good adsorption sites via the lone pair of electrons residual on the oxygen atoms while Tannins aids in forming the inhibitor protective layers on the metal surface with an adsorption mechanism on the oxide films. Thus, from the results and the role of each of phytochemical constituents in prevention of corrosion as stated above, the leave of *Cassia oxcdentalis* is expected to have high inhibitive properties, because *Cassia oxcdentalis* extract has Alkaloid, Tannins, Flavonoids, Cardiacglycoside all highly present.

### 3.2 Corrosion Rate

Figure 2 shows the weight loss of the mild steel coupon in the control solution is high, reason being that 2M HCL solution aid in the high corrosion rate and also because of the absence of any inhibitor, thus the mild steel coupon disintegrates faster



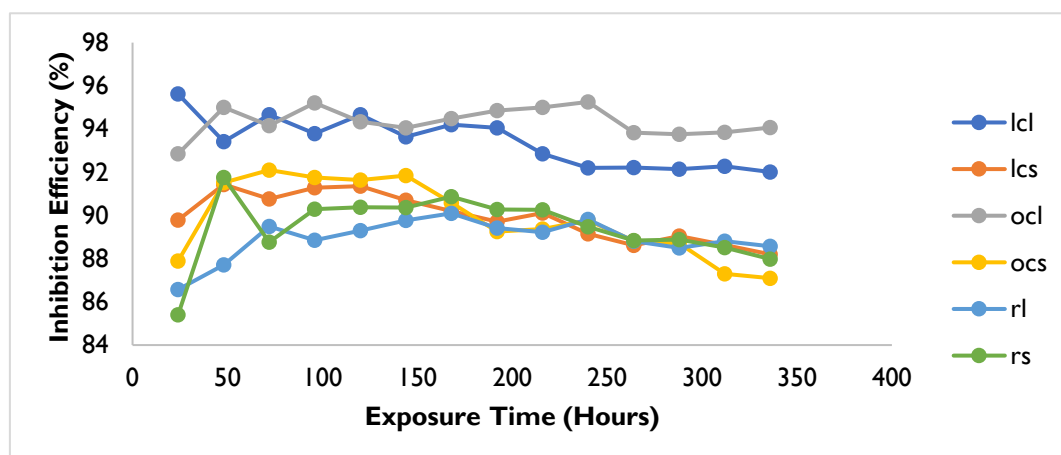
**Figure 2:** Variation of Weight Loss with Different Exposure Time on Mild Steel in 2M HCl

Key cs= Control solution, lcl= *lantana camara* leave, lcs= *lantana camara* seed, ocl= *Cassia occidentalis* leave, ocs= *Cassia occidentalis* seed, rl= *Rusinus comuinus* leave, rs= *Rusinus comuinus* seed.

The corrosion rate is seen to be significantly high as observed in this study. The values of weight loss of mild steel coupon (g) differ with the exposure time (hours) for mild steel immersed inside the control solution and that immersed in the test media (in presence of inhibitor), *lantana camara* leaves, *lantana camara* seed, *Cassia occidentalis* leave, *Cassia occidentalis* seed, *Rusinus cumminus* leave and *Rusinus cumminus* seed. It was observed that corrosion rate of metal increase with increase in time of exposure. Accordingly, the *Cassia occidentalis* leaves extract, *lantana camara* leaves extract show less corrosion rate compare to their seeds extracts, but the seed extract of *Rusinus cumminus* exhibit less corrosion rate than its leave extract.

### 3.3 Inhibition Efficiency

Figure 3 compare the inhibition performance of each extract on the mild steel coupon.



**Figure 3:** Variation of inhibition efficiency and exposure time

The magnitude of corrosion inhibition and the inhibition efficiency of *lantana camara* (leaves and seeds), *Cassia occidentalis* (leaves and seeds) and *Rusinus comuinus* (leaves and seeds) extract in corrosion of mild steel coupon in corrosive media was studied for 14days. Figure 3 shows that all the six immersed coupons were detected to have almost the same inhibition efficiency. Though, *Cassia occidentalis* leave shows great efficiency, this is

because of it has high phytochemical constituents present than other extracts which aids in the high prevention of corrosion, it showed 94.266% of inhibition of efficiency.

The result obtained from *lantana camara* extract (leaves and seeds) shows some great inhibition properties as though the efficiency in that of leaves is higher than that of the seeds. *Lantana camara* leaves extract formed high protective film on the mild steel coupon surface in the presence of corrosive media. *Cassia occidentalis* extract (leaves and seeds) also exhibits the presence of inhibition, same as that of *lantana camara* the inhibition efficiency of the leaves extract is higher than that of seed extract. But unlike *Rusinus comuinis* extract have shown inhibition properties similar to that of *lantana camara* extract and *Cassia occidentalis*, *Rucinus cummunis* seeds extract is higher (89.431%) than that of the leaves extract (88.929%). This also because of the rate of the phytochemicals constituent's present in each extract.

#### 4. Conclusion

From this research work, natural (green) plant extracts (leaves and seeds) have shown a great alternative for inhibition of corrosion in metals. Though some plants may have low inhibition properties despite their abundance in the locality, the reason being that the low amount of the physiochemical constituent need to stop or slow process of the corrosion on the material when exposed to the atmosphere. The plants leaves and seeds investigated showed the presence of all the chemical compounds needed for corrosion prevention except saponins and Anthraquinones which is scarcely available in the extracts investigated. Their absence will have no serious consequence when it comes to corrosion inhibition is mild steel. The other compounds are available in moderate to high amounts and can equalize the deficiency that may arise as a result of the little presence of saponins and Anthraquinones.

Most plants that are abundant and have little or no economic value (not for food) have potentials in the prevention of corrosion; they are mostly a waste and therefore less expensive, can create job opportunities and most important it is environmentally friendly.

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