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A Study of Corrosion Combating Efficacy of Leaves and Stem Extract of Naturally Occurring Plants *Solanum xanthocarpum* and *Salvodera persica* on Aluminium in 2N HCl Solution

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Authors' contributions

This work was carried out in collaboration among between both authors. Author NM designed the study, managed the analyses of the study, and wrote the first draft of the manuscript. Author RKU wrote the protocol and managed the literature searches. Both authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Weight loss and gasometric methods have been used to study the inhibiting effect of extract of leaves and stem of *Solanum xanthocarpum* and *Salvodera persica* on the corrosion of aluminium in 2N HCl solution was evaluated. The results indicated that the corrosion inhibition efficiency increased on increasing plant extract concentration. Percentage inhibition efficiencies obtained from weight loss were reasonably in good agreement with those obtained from gasometric method. The analysis of data shows that combating efficacy of *Salvodera persica* is more than that of *solanum xanthocarpum*. However leaves extract of *Salvodera persica* show more combating power than stem extract of *salvodera persica*.

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Keywords: Solanum xanthocarpum; salvodera persica; corrosion rate; weight loss; corrosion combating efficacy; surface coverage; volume change.

1. INTRODUCTION

Aluminium Metal is considered to be very important element in the science of corrosion protection since it has a large number of applications, like in foils from wrapping, in every engineering industry as well as in high technological application in aeronautics, power sources and electronics [1-4]. Aluminium and most of its alloys are observed to have a very good corrosion resistance when exposed to natural atmosphere and other environments because surface of aluminium and its alloys get covered with a natural oxide film [5]. In presence of strong acids, bases and aggressive ions like chloride, this protective oxide film is generally dissolved and corrosion takes place [5]. In presence of various plant extracts, the corrosion of Aluminium and its alloys can be prevented.

Different parts of plants like stem, leaves, bark and fruits can be used as green inhibitors [6].These inhibitors have hetero atoms O, N, S which have higher basicity and electron density. Availability of non-bonding (l.p) and p electrons in inhibitor molecule facilitate electron transfer from the inhibitor to metal [7]. A coordinate covalent bond involving transfer of electron from inhibitor to metal surface may be formed. Thus corrosion retards to a great extent [8]. These green corrosion inhibitors are ecofriendly, non-toxic and cost efficient which led to their greater use in current scenario.

In present work, anticorrosion activity of leaves and stem extract of *Solanum xanthocarpum* and *Salvodera persica* have been studied in 2N HCl solution. *Salvodera persica* also known as meswak or arak tree is a subtropical tree of medicinal interest, belonging to the family salvodoraceae, native to Arabian Peninsula and India [9,10]. *Salvodera persica* plant has number of medicinal applications and almost all parts have been found to be having medicinal activities [11,12]. It has alkaloid salvadurine, tannins, saponins, flavonoids and sterols [13]. *Solanum xanthocarpum* is an annual herb which grows as wild plant in many parts of India [14]. It is known as kantkari or bhatkatiya [14]. *Solanum xanthocarpum* possesses antihistamatic, hypoglycemic, antibacterial properties [15]. It has several steroidal alkaloids like solanacarpine, solamargine and diosgenin [16,17].

2. EXPERIMENTAL DETAILS

2.1 Preparation of Metal Specimen

Aluminium specimen of dimension 2.5 cm height, 2.5 cm width and 0.04 cm thickness were used for weight loss and gasometric studies. These were double washed with water, polished with emery paper, degreased with acetone and dried. A small hole was made at the upper part of each sample to hang them in test solution and then they were weighed *and* kept in small polythene bags to avoid the contact from direct air.

2.2 Preparation of Inhibitor Solution

Leaves and stem of *Solanum xanthocarpum* and *Salvodera persica* was collected, dried in dark and grounded in powder. The alcoholic

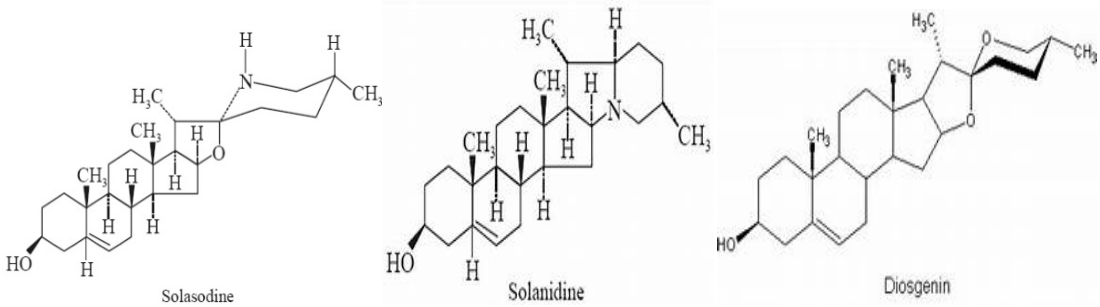

Fig. A. Different Alkaloids present in Plants

(Source- Parmar S, Gangwal A, Sheth N. Solanum xanthocarpum: A review, Der pharmacia letter, 2010; 2(4):373-383)

extract of leaves and stem in glass apparatus known as soxhlet. From this extract, test solution containing 0.2%, 0.4%, 0.6%, 0.8% of the inhibitor of interest were prepared by dilution.

2.3 Medium

2N HCl was prepared by diluting AR grade HCl using highly accurate weighing balance and volumetric flasks.

3. METHODOLOGY

Weight loss and gasometric methods were used to study the corrosion combating efficacy of inhibitors.

3.1 Weight Loss Method

The initial weight of specimen were noted and they were immersed in the experimental solution with the help of V-shape capillary glass hooks. Experimental solution used was 2N HCl in absence and in presence of various concentration of the inhibitors. After 15 minute the specimen were taken out, washed with distilld water and dreid completely and their final weight were noted with a weighing balance having accuracy upto 4 decimal point.

From the weight loss, the corrosion rate in mili meter per year (mmpy), inhibition efficiency of inhibitor was calculated using the formula- [18, 19]

$$\eta\% = \frac{100\ (\Delta W_o - \Delta W_i)}{\Delta W_o}$$

ΔW_o = weight loss of sample in uninhibited solution
ΔW_i = weight loss of sample in inhibited solution

$$\text{Corrosion rate (C.R).} = \frac{87.6\ \Delta W}{ATD}$$

ΔW = weight loss of specimen in mg
A = Exposed area of specimen in cm^2
T = Time of exposure in hours
D =density of metal in g/cm^3

The degree of surface coverage (θ) by inhibitor can be calculated as [20]

$$\theta = \frac{(\Delta W_o - \Delta W_i)}{\Delta W_o}$$

Effect of various concentration of *Salvodera persica* extract on inhibition efficiency for Aluminium in 2N HCl are summarized in Table 2.

3.2 Gasometric Method

Gasometric method is based on the principle that corrosion in acidic media is characterized by the evolution of hydrogen gas resulting from corrosion reaction which is proportional to the rate of corrosion. 50 mL the corrodent was introduced into a reaction chamber, connected to burette through a delivery tube. A weighed metal specimen was dropped into the chamber and reaction chamber was quickly closed to avoid escape of hydrogen gas. The volume of hydrogen (in mL) in the level of paraffin oil in the gasometric equipment. The same experiment was repeated in presence of inhibitor.

Table 1. Change in percentage inhibition efficiency with concentration of inhibitor, *Solanum xanthocarpum*

Concentration of Inhibitor	Weight loss in mg (ΔW)	Inhibition efficiency (η %)	Surface coverage (θ)	Corrosion rate (mmpy) *(C.R)*	Log $\left(\frac{\theta}{1-\theta}\right)$
Leaves					
Uninhibited	208.5			4329.38	
0.2%	51.3	75.39	0.7539	1065.21	0.4862
0.4%	27.9	86.61	0.8661	579.32	0.8107
0.6%	15.7	92.47	0.9247	326.00	1.0892
0.8%	11.4	94.53	0.9453	236.71	1.2330
Stem					
Uninhibited	208.5			4551.56	
0.2%	52.7	74.68	0.7468	1152.42	0.4697
0.4%	50.8	75.59	0.7559	1110.89	0.4908
0.6%	40.3	80.65	0.8065	880.41	0.6199
0.8%	33.6	83.85	0.8385	735.06	0.7153

Table 2. Effect of various concentration of *Salvodera persica* extract on inhibition efficiency for Aluminium in 2N HCl

Concentration Of Inhibitor	Weight loss in mg (ΔW)	Inhibition efficiency (η %)	Surface coverage (θ)	Corrosion rate (mmpy) *(C.R)*	Log $\left(\frac{\theta}{1-\theta}\right)$
Leaves					
Uninhibited	208.5			8625.55	
0.2%	42.4	79.63	0.7963	1756.67	0.5920
0.4%	39.8	80.90	0.8090	1646.62	0.6269
0.6%	6.52	96.87	0.9687	269.93	1.4906
0.8%	4.52	97.83	0.9783	186.88	1.6540
Stem					
Uninhibited	208.5			8476.04	
0.2%	55.1	73.54	0.7354	2242.56	0.4439
0.4%	39.1	81.24	0.8124	1589.93	0.6365
0.6%	24.2	88.36	0.8836	986.51	0.8803
0.8%	11.9	94.29	0.9429	483.81	1.2178

Table 3. Change in Hydrogen evolved per unit surface area with time for Aluminium in 2N HCl Solution in presence and absence of inhibitor, *Solanum xanthocarpum*

Concentration of inhibitor	Volume change(ΔV) in mL	Inhibition efficiency (η %)	Hydrogen evolution rate (CR_h)
Leaves			
Uninhibited	21.0		1.400
0.2%	5.2	75.71	0.340
0.4%	4.3	80.00	0.280
0.6%	2.4	88.57	0.160
0.8%	1.9	91.00	0.126
Stem			
Uninhibited	21.0		2.080
0.2%	8.4	59.61	0.840
0.4%	7.3	64.90	0.733
0.6%	6.6	68.26	0.666
0.8%	4.0	80.76	0.400

Table 4. Variation of Hydrogen evolved per unit surface area with time for Aluminium in 2N HCl Solution in presence and absence of inhibitor, *Salvodera persica*

Concentration of inhibitor	Volume change(ΔV) in mL	Inhibition efficiency (η %)	Hydrogen evolution rate (CR_h)
Leaves			
Uninhibited	21.0		2.266
0.2%	6.1	70.79	0.666
0.4%	4.6	77.87	0.480
0.6%	1.6	92.34	0.173
0.8%	1.2	94.00	0.106
Stem			
Uninhibited	21.0		2.080
0.2%	4.9	76.50	0.733
0.4%	4.3	79.30	0.423
0.6%	2.2	89.23	0.193
0.8%	1.5	92.63	0.132

Inhibition efficiencies and the hydrogen evolution rates for *Solanum xanthocarpum* and *Salvodera persica* leaves and stem extract on aluminium in 2N HCl were calculated from equation [21].

$$\eta\% = \left(\frac{CR_{blank} - CR_{inh}}{CR_{blank}}\right) x\ 100$$

$$CR_h = \frac{V_t - V_i}{t_t - t_i}$$

V_t = volume of hydrogen evolved at time t_t (mL)

V_i = Change in Volume of gas (mL)

CR_{blank} = Rate of Hydrogen gas evolution in uninhibited solution

CR_{inh} = Rate of Hydrogen gas evolution in presence of inhibitor

The change in Hydrogen evolved per unit surface area with time for Aluminium in 2N HCl Solution in presence and absence of *Solanum xanthocarpum* leaves and stem extract are summarized in Table 3.

Variation of Hydrogen evolved per unit surface area with time for Aluminium in 2N HCl Solution in presence and absence of *Salvodera persica* leaves and stem extract are summarized in Table 4.

4. RESULTS AND DISCUSSION

Corrosion combating efficacy of leaves and stem extract of *Solanum xanthocarpum* and *Salvodera persica* have been studied for aluminium in 2N HCl in blank and with different concentrations of inhibitor by weight loss and gasometric method.

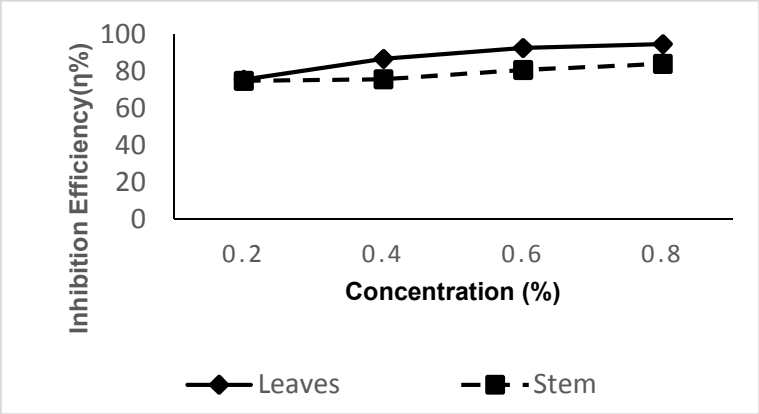

Fig. 1. Plot of Inhibition efficiency against for aluminium in 2N HCl solution in combination with different concentrations of *Solanum xanthocarpum* leaves and stem extract by weight loss method

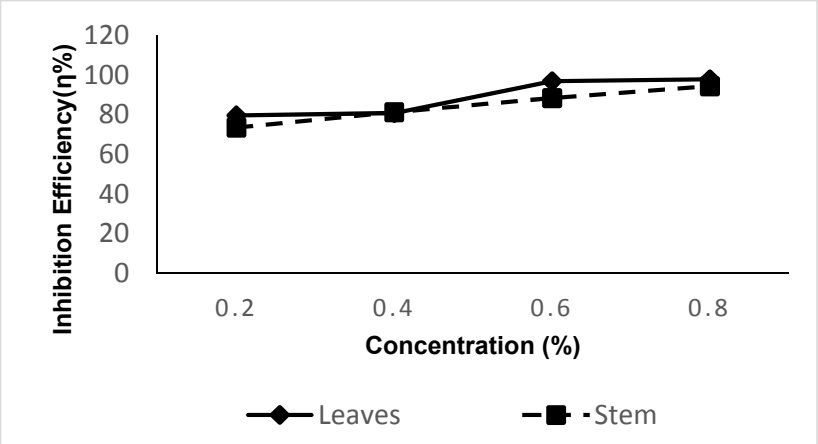

Fig. 2. Plot of Inhibition efficiency against for aluminium in 2N HCl solution in combination with different concentrations of *Salvodera persica* leaves and stem extract by weight loss method

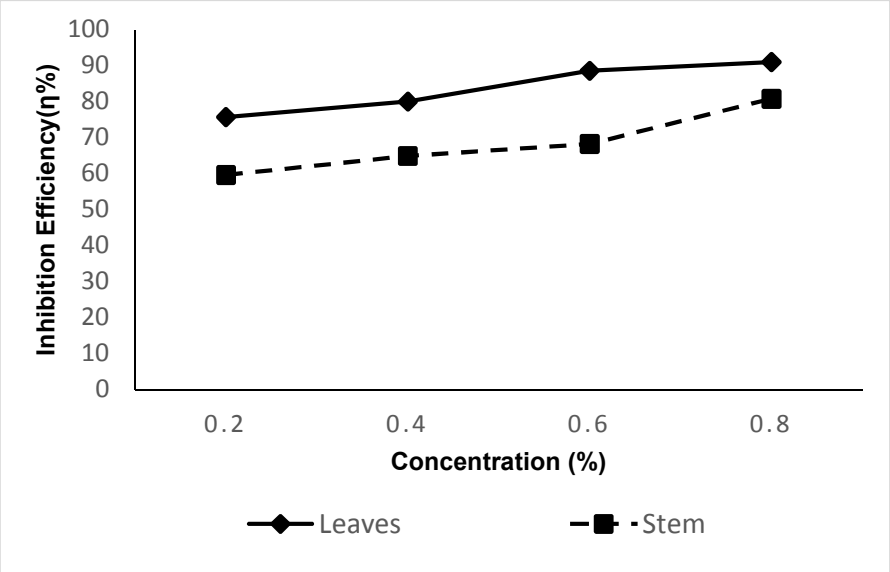

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Fig. 3. Plot of Inhibition efficiency against extract concentration in the presence of different concentrations of *Solanum xanthocarpum* in 2N HCl Solution on Aluminium by Gasometric method

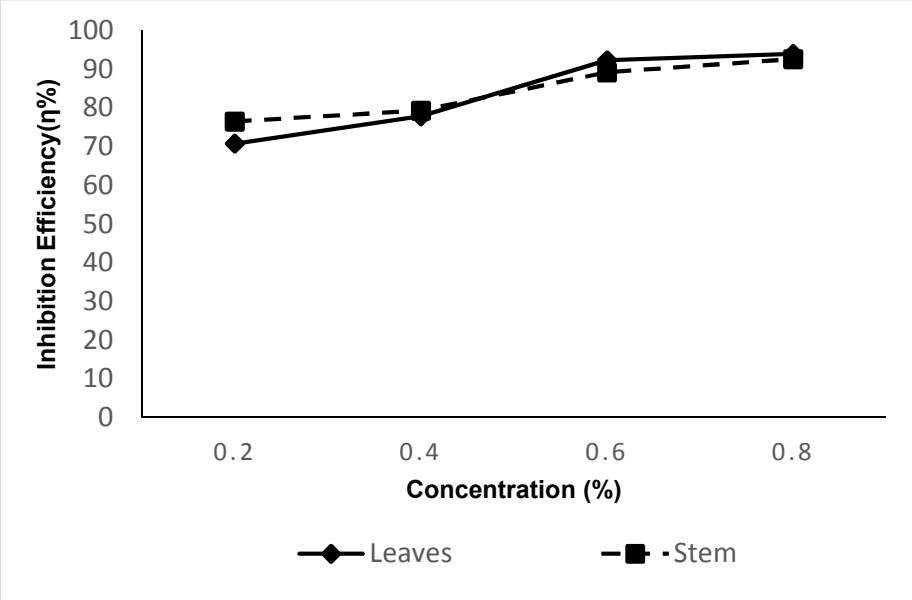

Fig. 4. Plot of Inhibition efficiency against extract concentration in the presence of different concentrations of *Salvodera persica* in 2N HCl Solution on Aluminium by Gasometric method

Table 1 and 2 show the change in inhibition efficiency with concentration of leaves and stem extract of *Solanum xanthocarpum* and *Salvodera persica* for aluminium in 2N HCl solution by weight loss method. The data revealed that the inhibition efficiency increased after the addition of inhibitors and corrosion rate decreases. The highest value for inhibition efficiency was

obtained for leaves and stem extract is 97.83% and 94.00% at 0.8% concentration of *salvodera persica*.

Table 3 and 4 shows calculated values of hydrogen evolution rate and inhibition efficiency for aluminium in 2N HCl in presence and absence of *Solanum xanthocarpum* and *Salvodera persica* extracts of leaves and stem. Maximum efficiency for leaves is 94.00% and 92.63% for stem extract for *Salvodera persica* plant. It means that both methods follow the same trend of results and are in good accordance with each other. The variations in inhibition efficiency with concentration of inhibitor are shown in Figs. 1, 2, 3 and 4 graphically. It is evident form Table 1,2,3,4 that the corrosion combating power of inhibitor is in proportional to its concentration and maximum efficiency is shown at highest concentration of inhibitor in all cases.

The plants in study have hetero atom O and N in their extract which are the atoms having higher electron density due to presence of lone pair of electron. The electrons present on these atoms are responsible for chemisorption on the surface of metal specimen. Due to chemisorption the active sites of metal surface are reduced and the acid has less probability of attack on the surface. More the concentration of inhibitor more is the surface coverage of metal and lesser are the sites for attack by acid. This is the reason that combating power of inhibitor increases with increase in its concentration. Leaves extract of both plants have more efficiency than stem extract. It may be because leaves have higher alkaloid content as compared to stem. These alkaloids contain the heteroatoms N, S and O responsible for their inhibitory properties.
The study shows that the extract of both plants may be used as good corrosion inhibitor in acid media without causing harm to environment and with least pollution. The extract can be used in many industries which involve acid in their works.

5. CONCLUSION

The present studies show that both leaves and stem extract of *Solanum xanthocarpum* and *Salvodera persica* are good corrosion inhibitor for aluminium in 2N HCl. The leaves were found to be a better inhibitor than the stem both in the presence and absence of inhibitor which could be attributed to high concentration phytochemical in it. Both methods used in the present studies are in good agreement with each other.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sangeetha M, Rajendran S, Sathiyabama J, Krishnaveni A. Inhibition of corrosion of aluminium and its alloys by extract of green inhibitors. Portugaliae Electrochemical Acta. 2013; 31(1):41-52.
2. Jayalakshmi M. Muralidharan VS. Inhibitors for aluminium corrosion in aqueous medium. Central Electrochemical Research Institute. 2011;15(3-4):315-340.
3. Singh A, Ahamad I, Quraishi MA. Piper longum extract as green corrosion inhibitor for aluminium in NaOH solution. Arabian Journal of Chemistry. 2016;9(2):S1584-S1589.
4. Sethi T, Upadhyay RK, Chaturvedi A, Mathur SP. Inhibition effect of nitrogen containing ligands on corrosion of aluminium in acid media with and without KCl. Polish Journal of Chemistry. 2007; 82(3):591-598.
5. Bereket G, Yurt A. The inhibition effect of amino acids and hydroxy carboxylic acids on pitting corrosion of alluminium alloy7075. Corrosion Science. 2001;43(6): 1449-1457.
6. Sharma P, Upadhyay RK, Chaturvedi A, Parashar P. Study of corrosion inhibition efficiency of naturally occurring *Argemone Maxicanaon* aluminium in HCl solution. Journal of Teaching and Research in Chemistry. 2008;15(1):21-27.
7. Rani BEA, Basu BBJ. Green inhibitors for corrosion protection of metal and alloy: An overview. International Journal of Corrosion. 2012;3-4.
8. Goldstein EM. The corrosion and oxidation of metals: Scientific principles and practical applications (Evans, U.R). Journal of Chemical Education. 1960;37(12): 662.
9. Tackholm V. Students' flora of Egypt. 2nd Ed. Cairo university publication, cooperative printing company, Beirou. 1974; 0074.
10. Nadkarni AK. Indian material medica. Popular prakashan, Bombay. 1976;1.

11. Almas K. Miswak (chewing stick) and its role in oral health. Postgraduate dentist. 1993;3:214-218.
12. Bos G. The miswak, an aspect of dental care in islam. Medical history. 1993; 37:68-79.
13. Sadhan-El R, Almaz K. A review on miswak and its effect on various aspect of oral health. The Saudi Dental Journal. 1999;11(2):80-87.
14. Kumar S, Pandey AK. Medicinal attributes of *Solanum xanthocarpum* fruit consumed by several tribal communities as food. BMC Complementary and Alternative Medicine. 2014;14:112.
15. Parmar S, Gangwal A, Sheth N. Solanumxanthocarpum: A review. Der Pharmacia Letter. 2010;2(4):373-383.
16. Siddiqui S, Faizi S, Siddiqui B. Structurally novel diterpenoid constituents from the stem bark of *Azadirachta indica.* Journal of the Chemistry Society Perkin. 1983;5(2):14-21.
17. Gupta MP, Dutt S. Chemical examination of the seeds of solanum xanthocarpum. The Journal of Indian Chemical Society. 1938; 15:95-100.
18. Talati JD, Gandhi DK. Corrosion of zinc in citric acid containing food colourants. Indian Journal of Technology. 1991;29(6): 277-282.
19. Ailar WH. Handbook on corrosion testing and evaluation. Electrochemical Society, John Wiley and Sons. 1971;174.
20. Dubey RS, Upadhyay SN. A review of electrochemical techniques applied to microbiologically influenced corrosion in recent studies. Journal of Electrochemical Society India. 1999; 5:489.
21. Obot IB, Umoren SA, Obi-Egbedi NO. Corrosion inhibition and adsorption behavior for Aluminium by extract of *Aningeriarobusta* in HCl solution: Synergetic effect of iodide ions. J. Mater. Environ. Sci. 2011;2(1):60-71.

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