Chemical Science & Engineering Research

Ariviyal Publishing

Research Article

DOI:10.36686/Ariviyal.CSER.2019.01.01.003

Chem. Sci. Eng. Res., (2019) 1(1), 16-24.

Evaluation of Antioxidant and Anticorrosion Activities of *Ligularia Fischeri* Plant Extract

Gomathi Manokaran[a] and Mayakrishnan Prabakaran*[b]

[a]*Department of Biotechnology, M.G.R. College, Hosur 635130, Tamil Nadu, India.*
[b]*Department of Crop Science, College of Sanghur Life Science, Konkuk University, Seoul 05029, South Korea.*

***Corresponding author E-mail address**: prabakarannitt@gmail.com; prabakaran@konkuk.ac.kr (M.Prabakaran)

ISSN: 2582-3353

Crossref

Publication details
Received: 30th July 2019
Revised: 27th August 2019
Accepted: 28th August 2019
Published: 30th August 2019

Abstract: The use of plant as antioxidant and green inhibitors is a huge topic of discussion by many around the world. A major search for natural and green products are taken seriously as it has numerous benefits than any other man made product to prevent oxidation and corrosion. The use of plant extract of *Ligularia fischeri* (*L. fischeri*) was investigated in various aspects to identify the potential in scavenging free radical and protecting aluminum specimen from 1M HCl. On investigating the TPC-TFC of *L. fischeri*, 253.11-102.18mg/g of each were found. The antioxidant assays like DPPH (89.2%), nitric oxide (83%), and hydrogen peroxide (83%) free radical scavenging were comparatively good to that of the standard ascorbic acid. Weight loss measurements proved that the *L. fischeri* is effective at 1000 ppm of concentration with 1M HCl at 303±1 K. The maximum inhibition efficiency of 91.90% was achieved. The AFM-SEM analysis showed the inhibiting nature of *L. fischeri* by forming protective layer on the surface of steel.

Keywords: *Ligularia fischeri*; antioxidants; corrosion; aluminum; AAS; AFM; SEM

1. Introduction

Oxidation is a major problem in many areas like human health, food producers, and so on.[1,2] Oxidation is caused by various elements one of which is free radicals namely nitric oxide, hydrogen peroxide, and superoxide dismutase (SOD), which when react with oxygen molecules around them leads to depletion of human health, and loss in product value.[3-5] These oxidation leads to severe economical loss in food industries as these cause spoilage of food at the end.[6] In industrial scale, oxidation in metal containers, aircrafts, and ships causes huge loss in quality of products and economy.[7,8] In the aspect of human health, when oxidative molecules are produced during the metabolic reaction at various sites in human body they are usually used by our own system.[9] But once any reaction which gives rise to surplus amount of oxidants on which the human cell cannot react tends to accumulate in blood and become reactive oxidative species (ROS). These ROS are the one that cause various diseases like neurodegenerative disorders, and many more.[10]

The oxidation in metal triggers a serious problem called corrosion in industrial sectors. They are mostly seen in industries which work in corrosive environments like salt surfaces (ships), and food processing industries.[11,12] Even in biomedical engineering, manufacturing of corrosion free metal implants is a challenging job as if it occurs after implantation in human body it will turn harmful.[13] This has become one reason to begin the search for effective corrosion inhibitor by many researchers around the world. There are several forms of corrosion inhibitor like natural, semi-synthetic, and synthetic which are used as per requirement by consumers.[14,15] In most cases, the identification of new and effective corrosion inhibitors of natural origin such as plants, pectin, amino acids, alkaloids, polyphenols, and fatty acids are widely encouraged as these are readily available, easy to extract, and cost effective.[16,17] There are experimentally proven evidence on green inhibitor which emphasize the role of active compounds such as saponins, and flavonoids in corrosion prevention.[18,19] Many individual components like folic acid, streptomycin, gallic acid, tannic acid, myricetin, and chitosan are identified as potential corrosion inhibitor for metals.[17] Though there are numerous works carried out by scientist all over the world on mild steel, and carbon steel; corrosion on aluminum is very limited. In this article, the use of *L. fischeri* as a green inhibitor was analyzed on aluminum in 1 M HCl solution under various conditions. *L. fischeri* is a perennial plant found in parts of Asia like Korea, Japan, and China. This plant is used in folk medicines for treating diseases like coughs, hepatic diseases, inflammations, jaundice, rheumatoidal arthritis, and scarlet fever.[20] Components as in Fig. 1, 11-hydroxy-eremophil l(10)-en- 2,9-dione (a); 1 ß, 1 l-dihydroxy-eremophil-9-ene (b); an aromadandrane (-) 4ß,7α-aromadendranediol (c); 1 ß,6α-dihydroxy-eudesm-4(15)-ene (d); Teucdiol A (e); Teucdiol B(f) and other components like eremophilane sesquiterpenoids, quercetin-3-O-b-D glucoside, pterodontriol-6-O-b-D glucopyranoside, and 5-caffeoylquinic acid were already been isolated from roots and leaves of *L. fischeri*.[21-23] Here the use of *L. fischeri* plant extract was

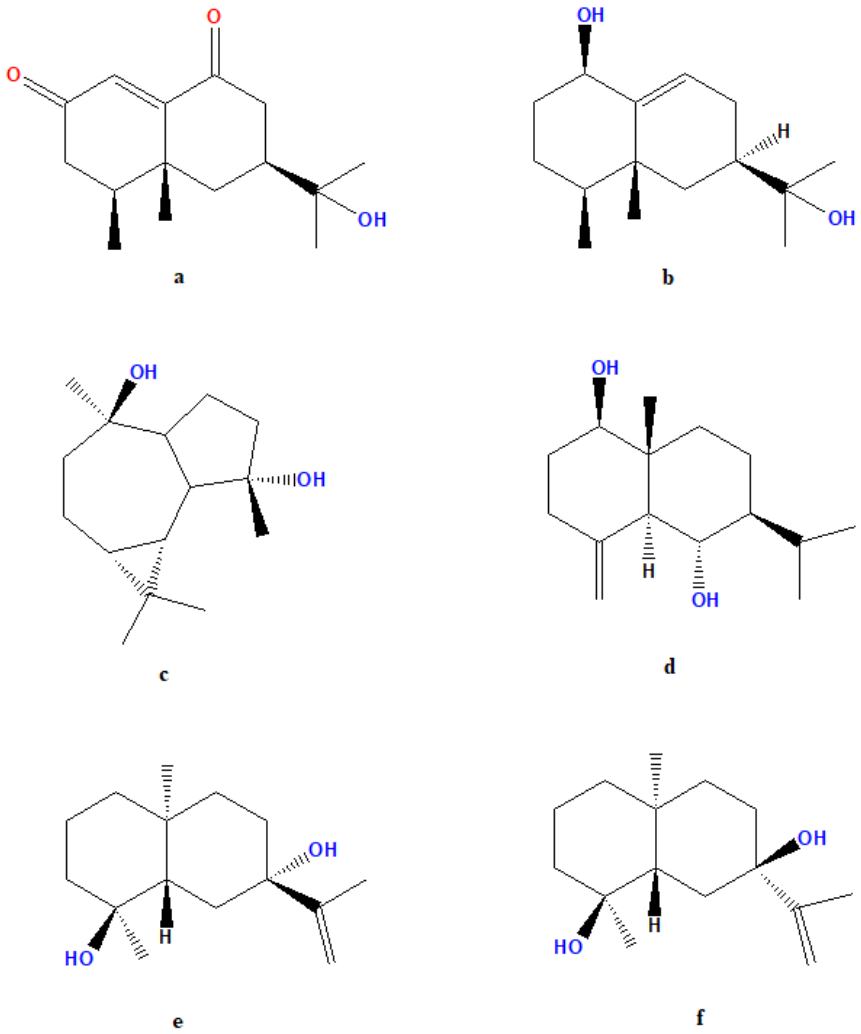

Fig. 1. Chemical structure of component in *L. fischeri* 11-hydroxy-eremophil l(10)-en- 2,9-dione (a); 1ß,11-dihydroxy-eremophil-9-ene (b); an aromadandrane (-)-4ß,7α-aromadendranediol (c); 1ß,6α-dihydroxy-eudesm-4(15)-ene (d); Teucdiol A (e); Teucdiol B (f).

extensively studied as antioxidant by testing its total phenol and flavonoid contents, free radical scavenging potential, and anticorrosive property by measuring weight loss, dissolved ions using AAS (atomic absorption spectroscopy), functional group assessment using FT-IR (Fourier-transform infrared spectroscopy), and surface film formation by atomic force microscopy (AFM), and scanning electron microscopy with energy dispersive X-Ray spectroscopy (SEM-EDX) .

2. Experimental Section

2.1. Preparation of Specimen

Aluminum specimen, the sample for corrosion study was made of 0.22 % C, 0.25 % P, 0.05 % S, 0.021 % Mn, 0.11 % Si, 0.09 % Cr, 0.11 % Ni, 0.12 % Mo and rest of aluminum. The specimen size was 3 × 1 × 0.5 cm which was polished by using 1/0, 2/0, 3/0, and 4/0 grit emery sheets.[24] After polishing, the specimens were washed in distilled water and degreased in acetone. Moisture was removed by drying, later which the specimens were stored in desiccator to prevent it getting wet throughout the experiments.

2.2. Plant Extract Preparation

The selected inhibitor, *L. fischeri* was collected from Seoul, Republic of Korea. The plant samples were thoroughly washed under running tap water to clean all the debris, sand, and unwanted materials. They were completely dried for few days and grained into fine powder. To 100 g of plant material, 3 L of methanol was added and kept at room temperature (RT) 303 ±1K for 72 h.[25] For complete extraction solvent was changed for every 24 h. Using Whatman grade 1 filter paper the extract was filtered followed by evaporation in rotatory evaporator. The pure form of extract was kept as such for the estimation of phenols, flavonoids, and antioxidant activity. For all corrosion related studies, known amount of pure form of extract was dissolved in 1mol•L−1 HCl to prepare 200, 400, 600, 800, and 1000 ppm of inhibitor solutions.

2.3. TPC-TFC Analysis

To test the total phenol and flavonoid contents (TPC and TFC) of *L. fischeri* extract methods previously described were followed.[26] For TPC estimation, 100 µL of extract, 900 µL of distilled water, and 1 mL of Folin-Ciocalteu reagent were added and kept aside for 5 min. To

this, 2 mL of sodium carbonate and 2 mL of distilled water were added and incubated for 1.5 h at 303 ±1K. Absorbance of blue color in the solution was measured at 765 nm in UV–visible spectra (UV 3000+, India) and the values were expressed in GAE (gallic acid equivalent) dry weight of the sample. For finding TFC, 3.4 mL of 30 % methanol, 0.3 mL of test sample, 0.15 mL of 0.3 M aluminum chloride hexahydrate, and 0.15 mL of 0.5 M sodium nitrite were mixed thoroughly and kept as such for 5 min. To this mixture, 1 mL of 1 M sodium hydroxide was added and absorbance was read in UV–visible spectra (UV 3000+, India) at 506 nm. Quercetin was taken as standard to express the values obtained.

2.4. Antioxidant Studies

The antioxidant activities [DPPH, nitric oxide, and hydrogen peroxide free-radical scavenging, reducing power, and phosphomolybdate method (total antioxidant capacity)] of the plant extract were done by reported methods with slight modifications.[27-29] For all the assays ascorbic acid was taken as standard.

2.5. Corrosion Inhibition in Aluminum by L. fischeri

2.5.1. Weight Loss Method

For measuring the loss of aluminum in 1 M HCl, experiments on different concentrations of inhibitor (200, 400, 600, 800, and 1000 ppm) at different temperatures (303, 313, 323, 333, and 343 ±1K) were performed with slight modification.[30] 100 mL of 1 M HCl with each concentration of inhibitor was tested individually at all the above mentioned temperatures for 3 h to measure the inhibition efficiency (IE %) by weighing the sample before and after immersion in test solutions. The following equation was used to calculate the inhibition efficiency:

$$IE\ \% = (W_0 - W_i)/ W_i \times 100 \quad (1)$$

$$\text{Surface coverage } (\theta) = IE\ \% / 100 \quad (2)$$

Here, W_0 and W_i are the weight loss by aluminum specimen without and with inhibitor respectively.

2.5.2. Atomic Absorption Spectroscopy (AAS)

The effect of inhibitor on aluminum specimen was observed using atomic absorption spectroscopy (model G8 908/Australia). *L. fischeri* was tested for its efficiency against 1 M HCl by incubating aluminum specimen in the absence and presence of inhibitor (200, 400, 600, 800, and 1000 ppm) for 3 h at 303 ±1K.[31] After immersion time, the corrodent solutions were observed for the concentration of dissolved ions in each solution to calculate the IE % using the following formula:

$$IE\ \% = B\text{-}A/B \times 100 \quad (3)$$

where, A and B represents the amount of dissolved ions in the uninhibited and inhibited (with different concentration of inhibitor) corrodent solutions.

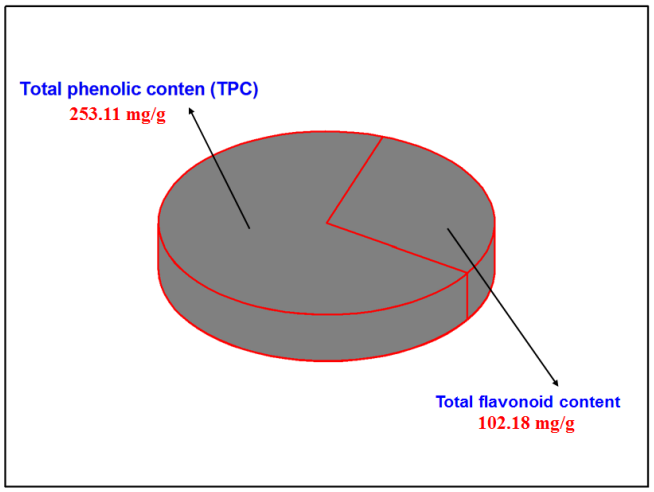

Fig. 2. Total phenolic and flavonoid content of *L. fischeri*.

2.5.3. Fourier-Transform Infrared (FT-IR) Spectroscopy

The functional groups present on the surface of the aluminum before and after inundation in 1 M HCl without and with 1000 ppm of *L. fischeri* extract for 3 h at 303 ±1K was thoroughly screened using FT-IR spectra (ATR-IR Affinity-1, Shimadzu, Japan). The results were compared to find the difference in spectrum of uninhibited and inhibited samples.[32]

2.5.4. Surface analysis by AFM and SEM-EDX

The surface study of aluminum specimen in 1 M HCl with and without 1000 ppm of inhibitor solution was studied using Atomic Force Microscopy (NTMDT, NTEGRA Prima, Russia) and SEM with accelerated 10 kV (JEOL Model, Coimbatore, India) coupled with energy dispersive X-ray spectroscopy (EDX, JEOL-Model JSM-6390, India). The specimen to be examined was kept in 100 mL of 1 M HCl with and without *L. fischeri* (1000 ppm) at 303±1 K for 3 h.[32] After incubation, the specimens were washed thoroughly in triple distilled water, and then dried to examine the morphological changes.

3. Results and Discussions

3.1. TPC-TFC Analysis

The TPC and TFC values of *L. fischeri* were identified as 253.11 and 102.18 mg/g (Fig. 2), respectively. Plants with good amount of active compounds are considered to have many beneficial effects on human.[33] This phenomenon is also helping in corrosion inhibition on metals like mild steel, carbon steel, zinc, and aluminium.[14] Active components of natural origin like phenols, flavonoids, tannins, and ellagic acid are known inhibitors of corrosion against acidic medium. These components are identified in plant parts and microalga.[17] In this report, *L. fischeri* a plant with known medicinal values in curing rheumatoidal arthritis, jaundice, and hepatic diseases was tested for its antioxidant and anticorrosion effects.[20] The presence of good amount of TPC and TFC shows that the extract of this plant can be taken for testing its antioxidant and anticorrosion efficacies.

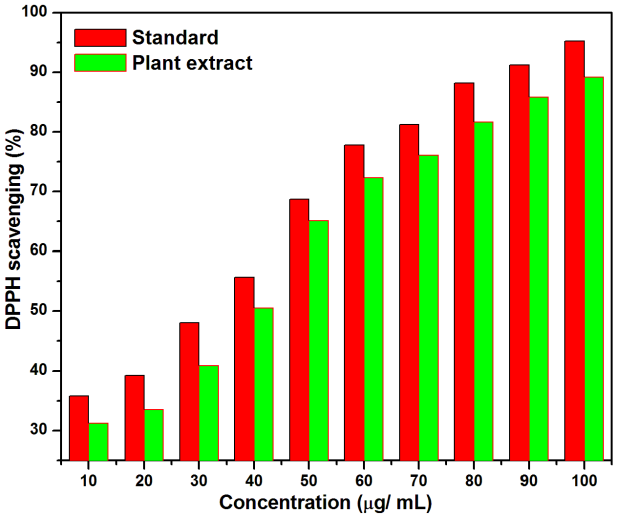

Fig. 3. Antioxidant activity of DPPH free-radical scavenging of *L. fischeri.*

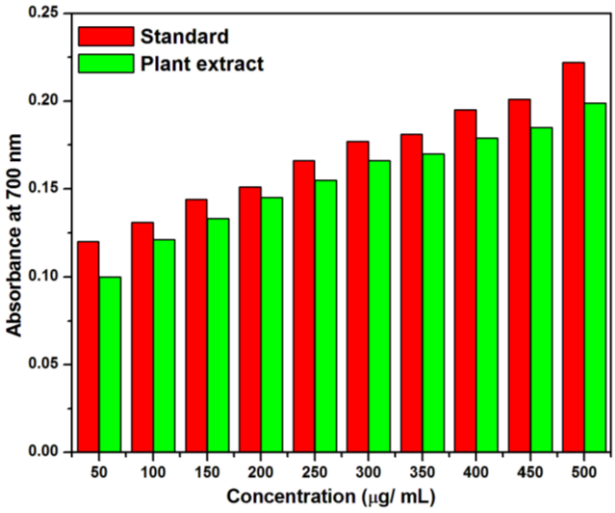

Fig. 4. Antioxidant activity of reducing power of *L. fischeri.*

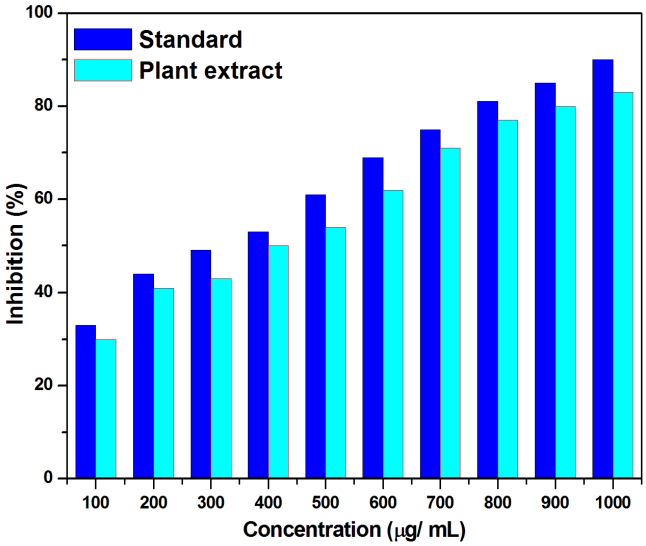

Fig. 5. *L. fischeri* plant extract on percentage nitric oxide scavenging.

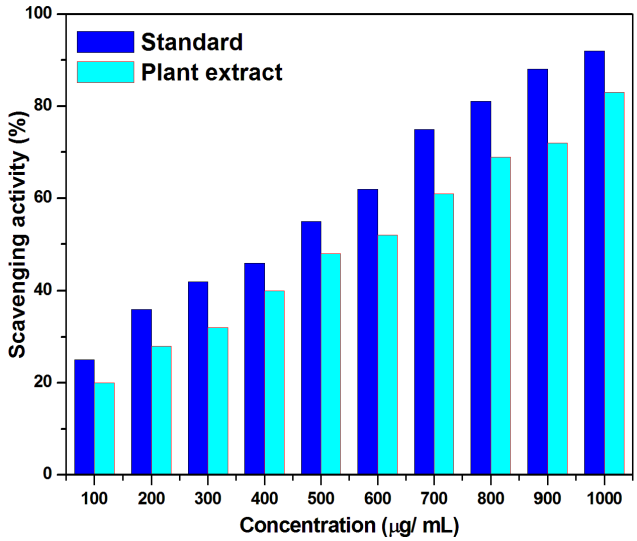

Fig. 6. Antioxidant activity of hydrogen peroxide assay of *L. fischeri.*

3.2. Antioxidant Studies

3.2.1. DPPH Free-Radical Scavenging Assay

The antioxidant activity of the extract *L. fischeri* was analyzed by experimenting different concentrations (10-100 µg/mL) of plant extract against DPPH, a stable compound with nitrogen atoms which gets reduced upon receiving atoms of hydrogen from antioxidant resulting to change in color from purple to yellow.[34] The antioxidant activity of *L. fischeri* increased with increase in concentration comparable to ascorbic acid. Higher scavenging activity (89.2 %) was observed at 100 µg/mL which was 31.2 % at 10 µg/mL (Fig. 3). Studies on many active compounds of plant origin have been proven effective in scavenging DPPH. Components namely cyanidin, delphinidin, malvidin, and anthocyanidins were identified as strong antioxidants.[35] Higher phenolic content contribute to higher antioxidant activity. This result shows that the higher TPC could be a cause for the antioxidant property of the plant extract.[36]

3.2.2. Reducing Power of Plant Extract

The Fe (III) reduction to Fe (II) by reductones donating hydrogen atom serves as an exemplary method to identify the antioxidant role of the phenolic components of *L. fischeri* plant extract.[37] Here, the electron donating characteristics of the plant extract increased with increase in concentration. As in Fig. 4, the reducing potential ranged from 0.1-0.199 for 50-500 µg/mL. This shows that the reduction is concentration dependent as per previous reports. Lactarius deliciosus a wild edible mushroom of Northeast Portugal origin was found effective in reducing free radicals likely by their hydrogen donating nature. The same phenomenon can be related to *L. fischeri* extract which established concentration based reduction.[38]

3.2.3. Total Antioxidant Capacity (Phosphomolybdate Method)

Studies had discussed about the correlation of total antioxidant capacity and the contents of plants especially in *Hemerocallis fulva Linn*., flowers.[39] The reduction of Mo by *L. fischeri* was 1214.44 mg/g which is evident to showcase the antioxidant efficacy in reference to ascorbic acid. The active components present in plants extract acts on Mo (VI) to reduce it to Mo (V). Polyphenols in food and medicinal plants comprise of glycosides with hydroxyl groups are found as effective antioxidants. The diverse variety of phenolic compounds namely tannins, flavonoids, and phenolic acids are involved in curing inflammation, cancer, and even antherosclerosis.[40] Thus the result

Table 1. Inhibition efficiency of *L. fischeri* for different concentrations against aluminum in 1 M HCl at room temperature (303±1 K) by weight loss measurement.

Conc. (ppm)	W (mg·cm^{-2})	θ	IE %	σ[a]
Blank	0.1001	-	-	-
200	0.0555	0.4455	44.55	0.04
400	0.0401	0.5994	59.94	0.03
600	0.0322	0.6783	67.83	0.01
800	0.0202	0.7982	79.82	0.05
1000	0.0081	0.9190	91.90	0.09

[a]σ is the standard deviation

Table 2. AAS study of dissolved aluminum ions in corrodent solution against 1 M HCl without and with different concentrations of inhibitor.

Conc. (ppm)	Amount of aluminum corrodant (mg/l)	IE (%)	σ[a]
Blank	35.21	-	-
200	28.88	17.97	0.09
400	21.01	40.32	0.11
600	15.32	56.48	0.05
800	11.01	68.73	0.09
1000	08.21	76.68	0.08

[a]σ is the standard deviation

excerpts the total antioxidant activity might be due to the involvement of phenols, flavonoids, and several other active compounds present in *L. fischeri*.

3.2.4. Nitric Oxide Free Radical Scavenging

The nitric oxide uses Griess reagent to quantify the production of nitrite and nitrate when nitric oxide reacts with oxygen.[41] The nitric oxide scavenging effect of the plant extract showed appreciable percent of activity based on the concentration i.e 100-1000 µg/mL of the extract 30-83% nitric oxide scavenging (Fig. 5). This result matches with various other reports for instance Actinidia arguta stem where antioxidant acts based on the concentration of the extract. Different fractions of A. arguta were seen inhibiting nitric oxide aggregation by preventing the excessive activation of macrophages in murine macrophage cell RAW 264.7 that was likely taking place by the action of phenolic acids.[42]

3.2.5. Hydrogen Peroxide Free Radical Scavenging

The *L. fischeri* extract also produced same effect on hydrogen peroxide free radical like all other antioxidant assays performed. The plant components acted on the hydrogen peroxide was found to be dose dependent as represented in Fig. 6. Here, 100 µg/mL of plant extract expressed 20 % scavenging activity which increased for consecutive concentrations. The highest percentage (83 %) of hydrogen peroxide scavenged was at 1000 µg/mL. This may be due to the presence of large number of phenols or active compounds at higher concentration which react with hydrogen peroxide to reduce as water in a dose dependent manner.[43]

3.3. Corrosion Inhibition in Aluminum by Plant Extract

3.3.1. Weight Loss Method

The inhibition efficiency of the plant extract was calculated by examining the aluminum specimen by weight loss method. Here, use of various concentrations (200, 400, 600, 800, and 1000 ppm) of *L.*

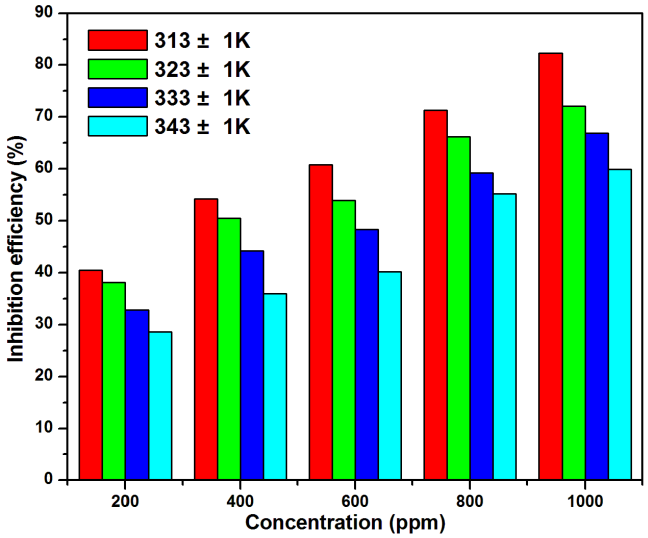

Fig. 7. Inhibition efficiency on aluminum by *L. fischeri* at different temperatures against 1 M HCl.

fischeri at different temperatures (303, 313, 323, 333, and 343 ±1K) were made to get an idea about the possible condition for the effective use of plant extract on aluminum against 1 M HCl. The most favorable concentration and temperature were identified as 1000 ppm and 303±1 K with 91.90 % IE which decreased at other temperatures and concentrations, Table 1 and Fig. 7. These results were concordance with previously published reports. The corrosion inhibition study on mild steel with *Curcuma longa* extract was highly affected by temperature and concentration of the extract. It was evident that increase in concentration as a cause for increased adsorption coverage reducing corrosion rate; in contrast increase in corrosion rate was observed at higher temperature due to more dissolution of metal.[44]

3.3.2. Atomic Absorption Spectroscopy

The analysis of dissolved ions in corrodent solution without inhibitor with that of corrodent solution with different concentrations of inhibitor (200, 400, 600, 800, and 1000 ppm) were

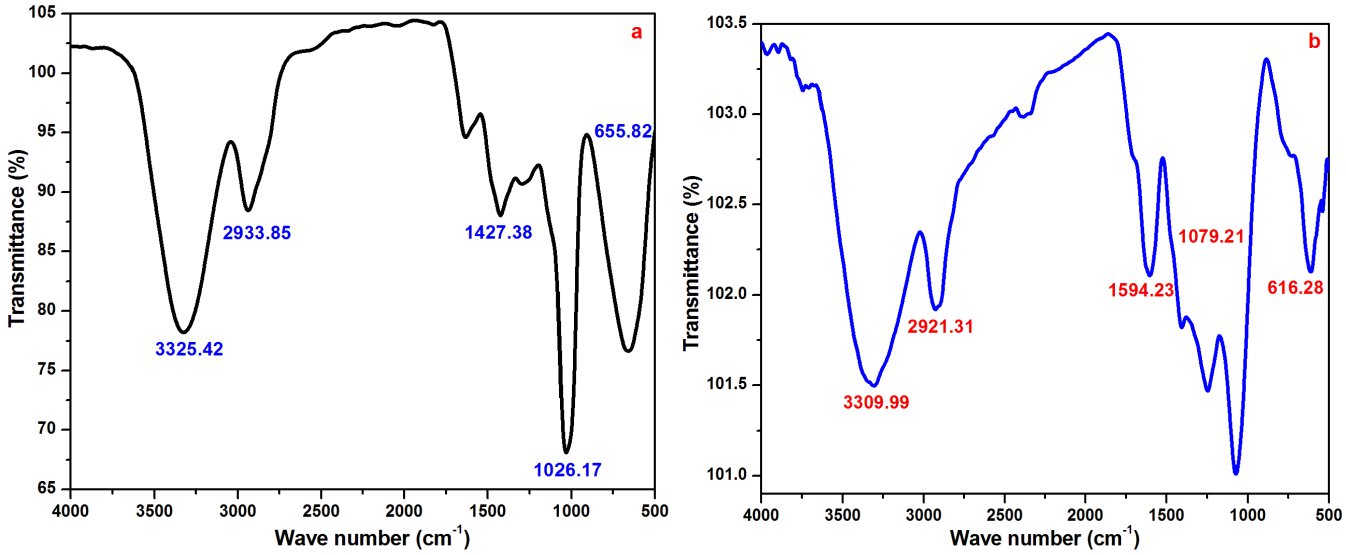

Fig. 8. FT-IR spectrum of aluminum a) 1 M HCl and b) presence of 1 M HCl with 1000 ppm of *L. fischeri* extract.

examined through AAS. The results (Table 2) were in correlation with mass loss measurement which exhibited corrosion inhibition in concentration dependent manner. Maximum level of inhibition against 1 M HCl corrosion was 76.68 % with 1000 ppm at 303 ±1K. A study on citric acid inhibitor preventing aluminium pigment corrosion, the possible reason for corrosion reduction was identified as the aluminium(III)–citric acid-chelate complex as a result of interaction between aluminium pigment and citric acid.[45] The inhibition efficiency of the plant extract based on concentration apparently happens by the adsorption of active constituents of *L. fischeri* onto the surface of metal forming protective film thereby prohibiting oxidation and reducing the aluminum ion diffusion in the corrodent solution.[46]

3.3.3. Fourier-Transform Infrared Spectroscopy (FT-IR)

The Fig. 8a, of FT-IR, spectrum representing 3325.42 cm^{-1} broad band assigned to O-H (alcohols) stretching, whereas 2933.85 cm^{-1}, 1427.38 cm^{-1}, 1026.17 cm^{-1}, and 655.82 cm^{-1} are characteristic of C-H, C=C, C-O-C, and C-C stretching vibrations, respectively. Fig. 8b, of FT-IR, spectrum representing 3309.99 cm^{-1}, 2921.31 cm^{-1}, 1594.23 cm^{-1}, 1079.21 cm^{-1}, and 616.28 cm^{-1} are characteristic of C-H, C=C, C-O-C, and C-C stretching vibrations, respectively. In both the cases shift in spectrum were observed which was majorly owing to the interactions of aluminum with *L. fischeri* extract which possess mixture of chemical constituents expressing adsorption behavior to form protective film. This phenomenon was identified in many plants based inhibitor for instance Epimedium extract which was aforesaid as an effective anticorrosive product.[32] In addition the presence of O-H and C-N, functional groups with nitrogen and oxygen atoms shows the interaction of inhibitor and metal heading toward corrosion reduction.[46] Likewise *L. fischeri* can also be added as a wonderful corrosion inhibitor against 1 M HCl.

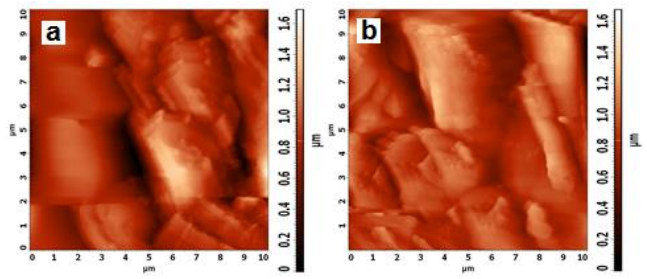

Fig. 9. 2D AFM micrographs of aluminum a) 1 M HCl without inhibitor and b) 1 M HCl with 1000 ppm of *L. fischeri* extract.

3.3.4. Surface Analysis

3.3.4.1. Atomic Force Microscopy (AFM)

Fig. 9, depicts 2 dimensional (2D) micrographs of aluminum in 1 M HCl without and with 1000 ppm of *L. fischeri* extract. This functions by tapping the surface of metal thereby producing reliable topographic images showing peaks and pits formed by the effect of acid and inhibitor. In Fig. 9a, the average roughness was 155 nm for aluminum in 1 M HCl while the same was 141 nm for aluminum in 1 M HCl with 1000 ppm inhibitor. Rougher surface was prevalent on metal without inhibitor causing severe damage. On the other hand (Fig. 9b), the roughness and pits on the surface was seen greatly reduced presumably by the formation of protective layer by the plant extract that gets adsorbed to the metal surface to prevent it from acid attack.[32]

3.3.4.2. Scanning Electron Microscopy and Energy Dispersive X-Ray Spectroscopy (SEM-EDX)

The SEM study in Fig. 10, shows the differences on the surface of metal owing to the effect of acid on aluminum without and with inhibitor. The difference in appearance of metal surface is made possible by the action of organic compounds with heteroatoms in their functional groups that is present in plant extracts.[44] The uninhibited specimen (Fig. 10a), shows larger pores, pits and huge rough surface all over the specimens which indicates the effect of 1 M HCl. In aluminum inhibited in 1000 ppm of *L. fischeri* (Fig. 10b), more smoothness and lesser pits were seen due to the prevention from acid attack by the formation of plant protective film. The percentage of various elements in both uninhibited and inhibited aluminum specimens were thoroughly studied using EDX. The

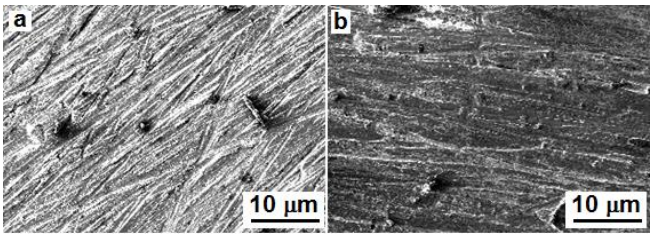

Fig. 10. SEM photographs of aluminum specimen immersed in (a) 1 M HCl and (b) 1 M HCl with 1000 ppm of inhibitor.

Table 3. EDX on aluminum metal composition immersed in 1 M HCl without and with 1000 ppm of *L. fischeri*.

Elements	Composition (atomic %)	
	Blank	Inhibited
C	6.32	8.11
Al	73.62	84.32
O	19.22	7.16
S	0.32	0.11
N	0.12	0.07
Mn	0.32	0.21
Mg	0.08	0.02

analysis revealed differences in the percentage of elements in both the samples as mentioned in Table 3. The uninhibited aluminum specimens had 73.62 % Al, 19.22 % O, 6.32 % C, 0.32 % Mn, 0.08 % Mg, 0.12 % N, and 0.32 % S (Table 3), whereas the aluminum specimens immersed with 1000 ppm of *L. fischeri* possessed 84.32 % Al and 8.11 % C. About 7.16 % was oxygen atom which was comparatively lesser than the uninhibited sample (Table 3). This shows the prevention of oxidation on aluminum by *L. fischeri* at a considerable rate like other earlier researches using citrus peel, henna leaves, and *Peganum harmala*.[17]

3.3.5. Corrosion Mechanism

In the Fig. 11, the possible mechanism of corrosion prevention is represented. As per, established reports there are few points to be considered while examining the action of plant extract on any metal specimen prone to corrosion under aggressive acidic condition. The reduction of corrosion by acidic or neutral environment was successfully tested by the use of sulphur compounds, nitrogen materials, aldehydes, quinine, chromate, organic dyes, and so on as inhibitors. The mechanism behind this may be by the adsorption of ions onto the surface of metals or by reducing the exposure of metal

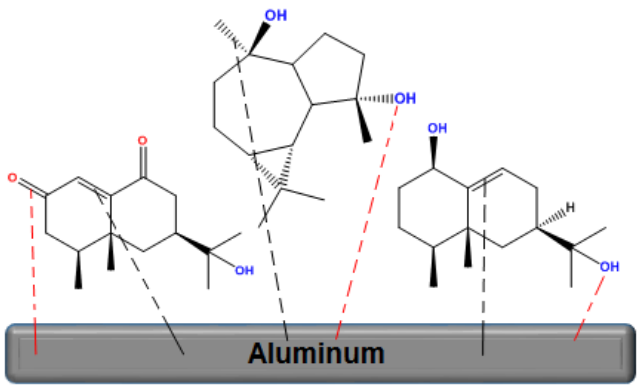

Fig. 11. Possible mechanism of corrosion inhibition by *L. fischeri* extract.

Table 4. Inhibition efficiency of *L. fischeri* in comparison with other green inhibitors.

S. No	Green inhibitor	η (%)
1.	*Ipomoea invulcrata*	89.10 [49]
2.	Coconut coir dust	80.00 [50]
3.	*Jasminum nudiflorum Lindl*	90.00 [51]
4.	*L. fischeri*#	91.90
5.	*Thymus algeriensis*	78.70 [52]

#**Present work**

to corrodent solution by shielding the metal surface which eventually cause decrease in diffusion rate or by changing the anodic or cathodic reactions.[14] Studies have shown effective inhibition by tobacco, opuntia, gram flour, and onion against alkaline and acidic solutions.[47,48]

3.3.6. Comparison with Green Inhibitors

Table 4, shows the inhibition efficiency of several other plant extracts namely *Thymus algeriensis*, coconut coir dust, *Ipomoea invulcrata*, and *Jasminum nudiflorum Lindl*., (78.70, 80.00, 89.10, and 90.00 % respectively) in comparison with the currently used *L. fischeri* (91.9 %) extract in inhibiting corrosion.[49-52] The IE % was higher in *L. fischeri* than other previously reported plant extract which gives convincing results.

4. Conclusions

This identification has many valuable points to consider *L. fischeri* as an effective antioxidant and inhibitor in prevention corrosion in acidic medium.

(i) The TPC and TFC were good enough in the extract.

(ii) The antioxidant assays like DPPH, nitric oxide, and hydrogen peroxide free radicals inhibition, reducing power, and phosphomolybdate method were competitive with each other producing almost same amount of oxidation prevention.

(iii) The weight loss method examined under different concentrations of plant extract at different temperatures conveyed the use of *L. fischeri* as efficient inhibitor.

(iv) AAS and surface analyses also indicate the presence of protective film on the metal surface.

(v) Since the prohibition of corrosion by *L. fischeri* was temperature dependant further analysis on *L. fischeri* in the thermodynamic and kinetics aspects would lead to more clear cut finding about the mode of action and other corrosion related studies in deeper.

Conflicts of Interest

The authors declare no conflict of interest.

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