Journal of Materials and Environmental Sciences
ISSN : 2028-2508
CODEN : JMESCN

J. Mater. Environ. Sci., 2019, Volume 10, Issue 8, Page 778-783

http://www.jmaterenvironsci.com

Adsorption behaviour of Ginger powder on Mild steel corrosion in Potable water

N.D. Suma[1*], S. Sreeja[2]

[1*]*KSM Devaswom Board College,Department of Chemistry and polymer chemistry, Sasthamcotta, Kollam P.O. 690 521, India*

[2]*KSM Devaswom Board College, Department of Chemistry and polymer chemistry Sasthamcotta, Kollam P.O. 690 521, India*

Received 12 February2019,
Revised 23 Aug 2019,
Accepted 24 Aug 2019

Keywords
- ✓ pipeline corrosion
- ✓ green inhibitor,
- ✓ adsorption study,
- ✓ weight loss study,
- ✓ ginger rhizome

sumagirish81@gmail.com

Abstract

Pulverised ginger rhizome was studied as corrosion inhibitor in potable water on mild steel corrosion. Corrosion measurements were done by weightloss and open circuit potential measurements. Optimum inhibitor concentration obtained for both corrosion rate and inhibition efficiency was 2g/100l. Adorption behaviour of Zingiber Officinale does not strictly follow Langmuir adsorption isotherm. Molecular interaction between the inhibitor molecules obey El Awady adsorption model. Adsorptions of pulverized Zingiber Officinale powder on mild steel coupons were further proved by its OCP values.

1. Introduction

Corrosion in potable water is a serious issue that affects public water distribution system. The water distribution network cannot be considered as inert system but a reactor interacting with the interior aqueous environments. During interaction the formation of unwanted deposits takes place [1]. The main source of deposit are particulate matter transported by water, dissolved oxygen, microbial activity, chlorides, sulphates and physicochemical reactions both at the pipe wall interface and within the water bulk [2,3]**.** Most water distribution systems have build up of iron corrosion products inside the iron pipes. When the structural integrity of these facilities is weakened by corrosion, the environment and public safety are threatened. So it is very important to control the corrosion of water pipes in distribution system. There are several techniques were developed to control and prevent corrosion in water supply system [4]. Among the different techniques, corrosion inhibitors find very important place in corrosion science. Green corrosion inhibitors especially plant parts play an important role in corrosion prevention because they are biodegradable, easily available and can be extracted by simple procedures with low cost [5-7].

It has been reported plant materials contain a wide variety of organic compounds and some of the compounds are including tannins, amino acids, alkaloids, and pigments [8]. These compounds contain hetero atoms such as P, N, S, O and show inhibition efficiency. Ginger, the rhizome of the *Zingiber officinale*, plays an important role in prevention of diseases [9]. Numerous active ingredients are present in ginger including terpenes and oleoresin. These compounds contain oxygen as heteroatom [10,11. Literature survey showed that ginger has been used as corrosion inhibitor in acid and neutral medium [21-16]. In this context present study focused to investigate corrosion inhibition and adsorption behaviour of ginger for the corrosion of mild steel in potable water by OCP and weight loss measurements.

2. Material and Methods

2.1. Substrate preparation

Mild steel coupons of size 2x3x0.05cm were mechanically cleaned by 100, 200, 400, and 600 grades of emery paper. Cleaned coupons where then washed with distilled water, degreased with acetone, dried in air, and kept in desiccators and weighed before experiment is going on **.**

2.2.Preparation of plant extract

Ginger (*Zingiber officinal Roscoe*) rhizomes were purchased from the local market of Sasthamcotta, Kollam district. One kilogram fresh ginger rhizome was cleaned, washed under running tap water, cut into small pieces, air dried and powdered. Different concentrations of powdered samples were then incorporated in to the corrosive medium.

2.3. Corrosion measurements

Weight loss measurement

Corrosion measurements were determined by the conventional weight loss technique. Mild steel coupons were mechanically polished by using different grades of emery paper ranging from 100 to 2000.After the pre treatment step each sample was cleaned in deionized water and dried with acetone. Samples were then weighed using Schimadzu AUX220 balance. Weighed coupons (Total exposed area = 1 cm^2 and remaining surface was covered using Teflon) were dipped for 144 hrs into the 100 ml potable water with and without different concentrations (1g, 1.5g, 2g, 3g, 5 g) of corrosion inhibitor taken in a beaker. After 144 hours these specimens were taken out and washed with double distilled water, dried well and weighed using electronic balance. Duplicate experiments were performed in each set of the test and the mean value of weight loss is measured. Using weight loss method we can calculate (1) Corrosion rate (2) inhibition efficiency (IE) (3) adsorption isotherms of the system.

(1) Corrosion Rate (mpy) =87.6xW/ρ. A.t**,** Where W = weight loss in g, D = density of the specimen in g/cm^3, A = Area of the specimen in cm^2, T = exposure time in hr.

(2) $IE\% = \frac{\text{Wo} - \text{Wi}}{w0}$, Where, W_0 and Wi is the weight loss value in absence and in presence of inhibitor**.**

2.4. Adsorption studies

Adsorption isotherms have been tested to study the adsorption behaviour of inhibitor on mild steel surface. Adsorption mechanism of inhibitor can be studied using different types of isotherms such as Langmuir, Freundlich, Temkin adsorption and El-Awady adsorption Isotherm. Langmuir adsorption isotherm is the simplest model to study adsorption mechanism. The degree of surface coverage, θ at each concentration of inhibitor was evaluated using the equation,

$$\theta \; = 1 - Wa/Wb,$$

Where W_b and Wa are the weight loss in corrodent without and with inhibitor respectively. If θ is the fraction of surface of adsorbent covered, (1-θ) is fraction of uncovered sites and C is the concentration, and then the Langmuir adsorption isotherm equation can be written as :

$$\boldsymbol{\frac{c}{\emptyset} = \frac{1}{K} + C}$$

This adsorption isotherm is followed if $\frac{c}{\emptyset}$ vs. C graph gives straight line with correlation constant (R^2) close to one.

2.5. Open circuit potential measurement

Open circuit potential of the mild steel coupons were measured in 100 ml drinking water in absence and presence of different concentrations of inhibitor (1g, 1.5g, 2g, 3g, 5 g) with the help of calomel electrode using a digital multimeter.

3. Results and discussion

3.1. Weight loss measurement

The corrosion of mild steel in potable water containing various concentrations of *Zingiber officinale* inhibitor at room temperature was studied by weight loss measurements. Fig.1and Fig 2.shows the corrosion rate and the inhibition efficiency of mild steel specimens immersed in 100 ml potable water for 144 hours as a function of inhibitor concentration at room temperature. The corrosion rate decreases very rapidly as the first concentration of the inhibitor is added to the blank system. The results show that the corrosion rate decreased as the concentration of *Zingiber officinale* reached up to 2 g/l00 ml tap water after that corrosion rate (CR) slightly increases. Decrease in CR is attributed to higher adsorption level of active inhibitor molecules from the inhibitor on the metal surface which prevents further corrosion.

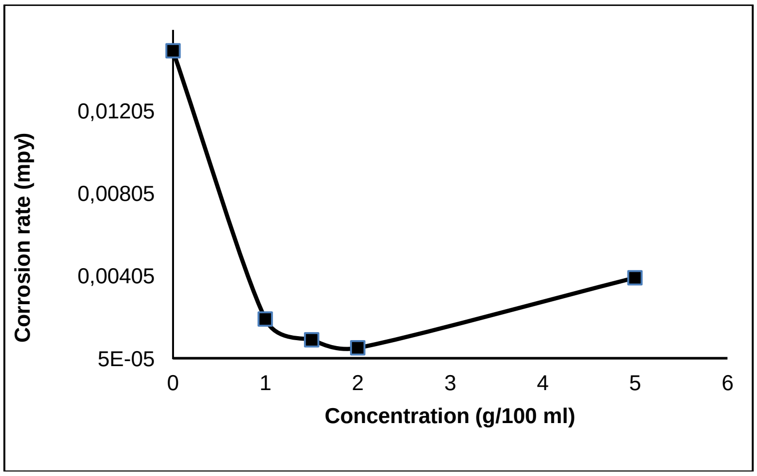

Fig.1. Variation of corrosion rate with concentration for mild steel Coupons in tap water containing different concentrations of *Zingiber officinale* at 32^{0}C

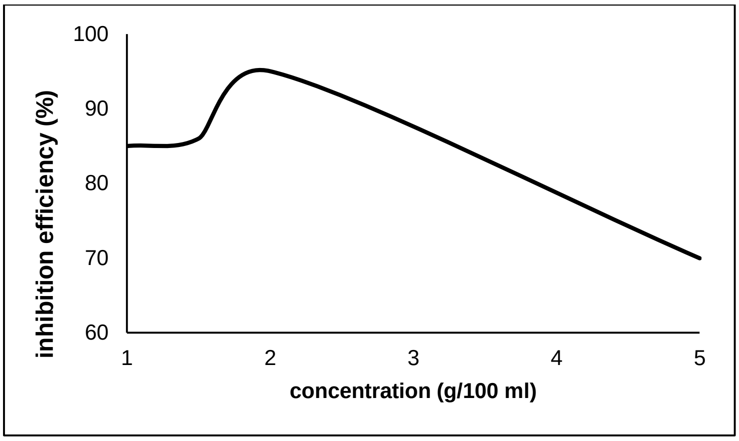

Fig.2. Variation of Inhibition Efficiency with Inhibitor Concentration for mild steel Coupons in 100 ml tap water containing Zingiber officinale at 32^{0}C

The maximum inhibition efficiency and the minimum corrosion rate were obtained at a concentration of 2 g/l00 ml of the inhibitor extract. Figure 2 shows that the inhibition efficiency obtained when adding 2 g/l00 ml of the Zingiber officinale is about 95%. The inhibition efficiency exhibited by the inhibitor may be due to the formation of adsorbed layer on the mild steel surface. The inhibition efficiency increases until 2 g of Zingiber officinale is added, after which the inhibition efficiency decreases slowly until it reaches 70 % at 5g and a corrosion rate of approximately 0.00444 mpy.

3.2. Adsorption behaviour study

From Fig.2 it is clear that the efficiency of a corrosion inhibitor mainly depends on its adsorption ability on the metal surface. The interaction between metal and the inhibitor can be understood by knowing the adsorption isotherm. In order to obtain the adsorption isotherm, the degree of surface coverage (θ) for various concentrations of the inhibitor has been calculated according to equation 3 from section 2.3.2. Langmuir isotherm was tested for its fit to the experimental data. If θ is the fraction of surface of adsorbent covered, (1 - θ) is fraction of uncovered sites and C is the concentration, and then the Langmuir adsorption isotherm equation can be written as :

$$\frac{c}{\emptyset} = \frac{1}{k} + C,$$

Where K is equilibrium constant which depends on temperature and strength of adsorption.

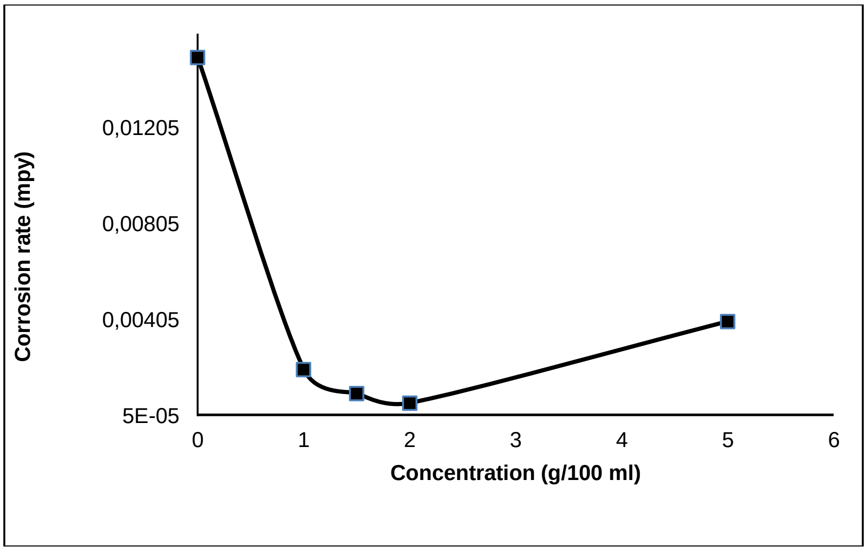

Fig.3. Variation of corrosion rate with concentration for mild steel Coupons in tap water containing different concentrations of Zingiber officinale at 32^{0}C

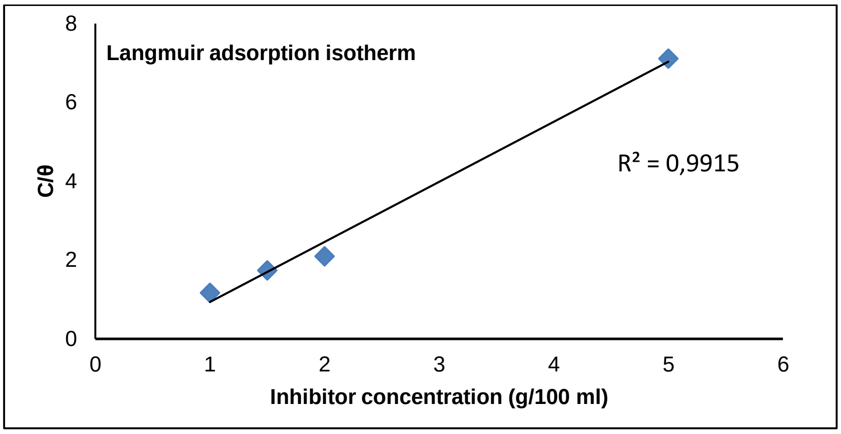

Fig.4. Langmuir isotherm plot for the adsorption of Zingiber officinale on the surf ace of mild steel.

This adsorption isotherm is followed if $\frac{c}{\emptyset}$ vs C graph gives straight line with correlation constant (R^2) close to one [17]. The plot obtained from the data was linear and slope is 0.9915. The deviation of slope from unity indicates molecular interaction among the adsorbed inhibitor species [18]. In this situation adsorption of inhibitor on mild steel plates does not strictly follows Langmuir equation.

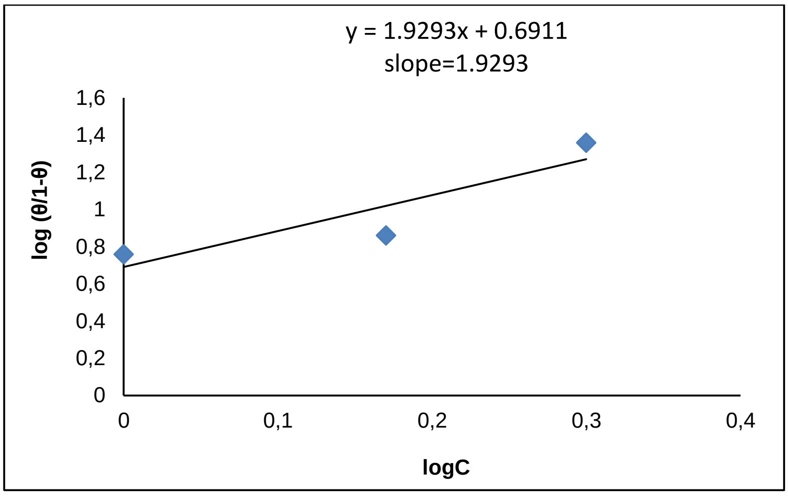

Fig.5. El-Awady isotherm plot for the adsorption of Zingiber officinale on the surface of mild steel

The experimental data have been then fitted into the modified form of Langmuir isotherm known as El-Awady isotherm. El-Awady isotherm is given by, $log \frac{\emptyset}{1-\emptyset} = \log K' + y \log C$, Where, $log \frac{\emptyset}{1-\emptyset}$ vs. log C will give a straight line with slope equal to y. It has been reported that $y < 1$ implies single inhibitor molecule occupies more than one active sites on the metal surface and for $y > 1$, it means a formation of multilayer [19]. In the present work slope obtained was 1.9293, indicates that each inhibitor molecule occupies more than one active site on the metal surface.

Open Circuit Potential measurement

Fig.6 shows the variation of open circuit potential (OCP) of mild steel with time in 100 ml tap water in the absence and presence of selected concentrations of inhibitor. The OCP values in the absence of inhibitor shifts towards more negative values. This may be due to the breakdown of the oxide film on the carbon steel surface [20]. However, in the presence of Inhibitor, the OCP shift towards more noble potentials with inhibitor concentration. This behaviour is attributed to the adsorption of inhibitor onto the steel surface.

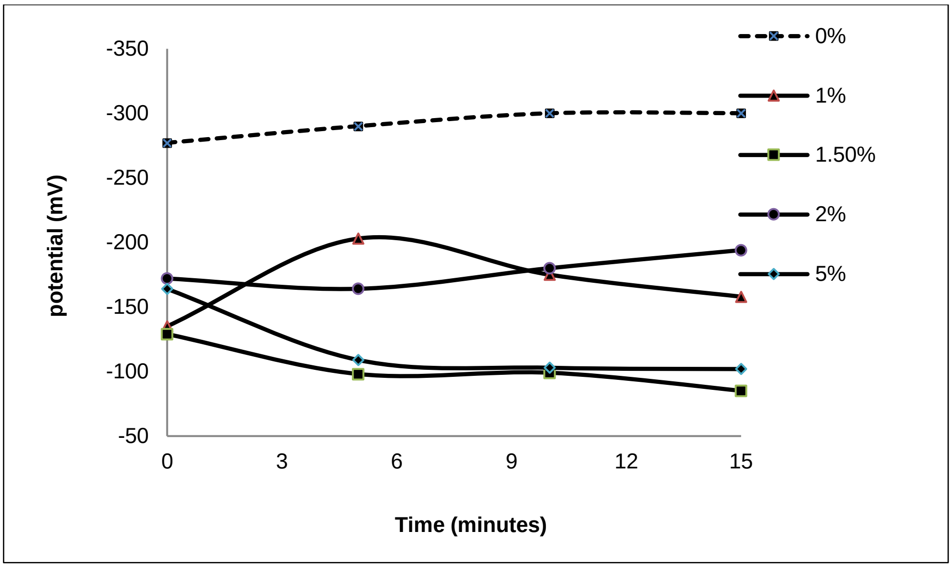

Fig.6. Variation of the open circuit potential (OCP) with time for a mild steel electrode immersed in 100 ml tap water, in the absence and presence of various concentrations of Zingiber officinale [Temp: 32°C]

Conclusion

In the present study pulverized Zingiber Officinale was used as corrosion inhibitor for mild steel coupon in drinking water system. Performance of the inhibitor in corrosive medium was evaluated by different techniques. Electrochemical characteristics of the plates were evaluated by open circuit potential measurement and found that optimum inhibitor concentration can effectively use for corrosion inhibition. Weight loss measurements were carried out to study the corrosion rate, inhibition efficiency and adsorption behaviour. The corrosion process was inhibited by the adsorption of inhibitor on the mild steel surface fits Langmuir isotherm followed by El Awady adsorption model. The maximum inhibition efficiency shown by Pulverized Zingiber Officinale was 95% for 2g concentration in100 ml water.

Acknowledgement: The authors acknowledge Kerala State Council for Science, Technology & Environment, for the financial support

References

1. V. Chawla, P.G. Gurbuxani, G.R. Bhagure, Corrosion of Water Pipes: a Comprehensive Study of Deposits, *J. Mineral and Materials Characterization and Engin.*, 11 (2012) 479, http://dx.doi.org/10.4236/jmmce.2012.115034
2. F. Echeverría, J.G. Castaño, C. Arroyave, G. Peñuela, A. Ramírez, A.J. Morató, Characterization of deposit formed in a water distribution system, *Ingeniare, Revista chilena de Ingeniería*, 17 (2009) 275-281, http://dx.doi.org/10.4067/S0718-33052009000200016

3. F. Codony, J. Morató, J. Mas , Role of discontinuous chlorination on microbial production by drinking water biofilms, *Water Res.*, 39 (2005)1896-1906, https://doi.org/10.1016/j.watres.2005.02.016
4. P. Torres-Lozada, K. A. Bueno-Zabala, L.G. Delgado-Cabrera, L.E. Barba-Ho, H. Cruz-Vélez , Corrosion control using hydroxide and bicarbonate alkalising agents in water drinking processes, *Water Eng. Sci. Discuss*, 8 (2015) 53, https://doi.org/10.5194/dwesd-8-53-2015
5. S. Abualnoun, Ajee, Study on Corrosion Inhibition of Brass in water using Horse Tail Herb as Green Inhibitor, *Eng. & Tech. Journal*. 32 (2014) 1992
6. A.E.S. Fouda , A.A. Nazeer, A.Y. Khateeb, M. Fakih, Cinnamon Plant Extract as Corrosion Inhibitor for Steel Used in Waste Water Treatment Plants and Its Biological Effect on *Escherichia coli* , *J. Korean Chem. Soc.*, 58 (2014) 359, https://doi.org/10.5012/jkcs.2014.58.4.359
7. K.S. Beena Kumari, Saraca indica (asoka) leaves extract as corrosion inhibitor for mild steel in potable water-a bioremediation method, *J. Indus. Pollu. Control.*, 29 (2013) 213
8. T.T. Bataineh, M.A.Al-Qudah, E.M.Nawafleh, N.A.F.Al-Rawashdeh, Sinapis alba extract as green corrosion inhibitor for aluminum in alkaline media, *Int. J. Electrochem. Sci.*, 9 (2014) 3543
9. S. Malhotra, A.P. Singh, Medicinal properties of ginger (Zingiber oficinale Rosc.) *Nat. Prod. Radi.*, 2 **(**2003) 296, http://hdl.handle.net/123456789/12292
10. A.K. Subramanian, S.Arumugam, K. Mallaiya, R.Subramaniam, Synergistic effect on corrosion inhibiton efficiency of Ginger affinale extract in controlling corrosion of mild steel in acid medium, *J. Korean Chem. Soc.*, 57 (2013) 672-676; http://dx.doi.org/10.5012/jkcs.2013.57.6.672
11. M. Mahboubi, Zingiber officinale Rosc. essential oil, a review on its composition and bioactivity, *Clinical Phytoscience,* 6 (2019) 1-12, https://doi.org/10.1186/s40816-018-0097-4
12. A.E.S. Fouda, A.A. Nazeer, M. Ibrahim, M.Fakih, Ginger Extract as Green Corrosion Inhibitor for Steel in Sulfide Polluted Salt Water, *J. Korean Chem. Soc.*, 57 (2013) 272, http://dx.doi.org/10.5012/jkcs.2013.57.2.272
13. A.M. Al-Fakih, M. Aziz, H.M. Sirat, Turmeric and ginger as green inhibitors of mild steel corrosion in acidic medium, *J. Mater. Environ. Sci.*, 6 (2015) 1480
14. A.F. Suryanto, M. Mahmood, Ginger extract as green corrosion inhibitor of mild steel in hydrochloric acid solution, *IOP conference series: Material Science and Engineering.*, 290 (2018) 012087, http://dx.doi.org/10.1088/1757-899X/290/1/012087
15. M.M.B. El-Sabbah, H.F.Y. Khalil, M.H. Mahross, B.N.A. Mahran, A.Z. Gomaa, *International Journal of Scientific & Engineering Research*, 6 (2015) 1502-1508
16. Y. Liu, Z. Song, W. Wang, L. Jiang, Y. Zhang, M. Guo, F. Song, N. Xu, Effect of ginger extract as green inhibitor on chloride-induced corrosion of carbon steel in simulated concrete pore solutions, *J. Cleaner Production.*, 214 (2019) 298 , https://doi.org/10.1016/j.jclepro.2018.12.299
17. P.B. Raja, A.K. Qureshi, A. B. Rahim, H. Osman, K. Awang, Neolamarckia cadamba *alkaloids* as eco-friendly corrosion inhibitors for mild steel in 1 M HCl media, *Corros. Sci.*, 69 **(**2013) 292 https://doi.org/10.1016/j.corsci.2012.11.042
18. R. Karthikaiselvi, S. Subhashini,_Study of adsorption properties and inhibition of mild steel corrosion in hydrochloric acid media by water soluble composite poly (vinyl alcohol-omethoxy aniline), *Journal of the Association of the Arab Universities for Basic and Applied Sci.* 24 (2014) 74-82, https://doi.org/10.1016/j.jaubas.2013.06.002
19. H.S. Gadow, M.M. Motaweab, H.M. Elabbasy, Investigation of myrrh extract as a new corrosion inhibitor for α-brass in 3.5% NaCl solution polluted by 16 ppm sulfide, *RSC Adv.*, **7** (2017) 29883-29898 https://doi.org/10.1039/C7RA04271J
20. J. Tang , H. Wang, X. Jiang , Z. Zhu , J. Xie, J.Tang , Y.Wang, M. Chamas , Y.Zhu, H. Tian, Electrochemical Behavior of Jasmine Tea Extract as Corrosion Inhibitor for Carbon Steel in Hydrochloric Acid Solution, *Int. J. Electrochem. Sci.*, 13 (2018) 3625-3642, https://doi.org/10.20964/2018.04.42

(2019) ; http://www.jmaterenvironsci.com