American-Eurasian Journal of Scientific Research 11 (3): 177-182, 2016
ISSN 1818-6785

DOI: 10.5829/idosi.aejsr.2016.11.3.22793

Moringa oleifera and *Psidium guajava* Leaves Extract as Low-Cost, Eco-Friendly Inhibitors of Corrosion on Mild Steel in an Acidic Media

[1]H.K. Idu, [1]P.A. Nwofe, [2]P.N. Kalu and [1,2]N.E. Idenyi

[1]Department of Physics, Faculty of Science,
Ebonyi State University, Abakaliki, Ebonyi State, Nigeria
[2]Department of Physics, Faculty of Science & Technology,
Federal University, Ndufu-Alike Ikwo, Nigeria

Abstract: In this study, the inhibitory properties of low-cost, eco-friendly corrosion inhibitors is investigated and reported. In particular, the effect of different volumes in the range 25-50 cm^3 of *Moringa Oleifera* and Psidium *guajava* Leaves Extract on the Corrosion Susceptibility of Mild Steel at different concentrations of an acidic environment (hydrogen tetra-oxosulphate VI, H_2SO_4), was used in the investigations. The experiment included casting the mild steel into rods; which were further machined and subsequently cut into coupons averaging a total surface area of 6.284 cm^2. Further, the coupons were weighed and immersed into different beakers containing 0.5M and 1.0M of hydrogen tetra-oxosulphate VI acid and the different volumes of the *Moringa oleifera* (MO) and *Psidium guajava* (PG) were introduced in the respective beakers and then labelled for easy and proper identification. The total exposure time was between 7 to 28 days, with the coupons removed every 7 days for weight loss measurements using the normal procedures. The results show that the corrosion penetration rate was very high in the control (without inhibitor) and was decreased when the inhibitor was introduced. However, the decrease was more pronounced (>80%) at a volume of 100 cm^3 of *Moringa oleifera* leaf extracts at 0.5M and 1.0M of the acidic media respectively. According to the findings, it was concluded that the volume of 100 cm^3 of *Moringa oleifera* leaf extracts at a concentration of 0.5M and 1.0M of the acidic media is the optimum conditions for reduced corrosion rate of mild steel in an acidic environment.

Key words: Acidic · Corrosion rate · Inhibitor · Concentration

INTRODUCTION

Environmental degradation has been identified as one of the commonest problems associated to man in the face of the ever-growing technologically advanced century. The consequences of corrosion on metals is a phenomena that has been known for ages and widely discussed in the literature, with different attempt by different research groups been reported on how to curb/eradicate this scourge. Different solvents are known to corrode metals, although these solvent are very useful in various applications. In the industry, acid solutions are mostly used for cleaning, descaling and pickling of steel structures and these processes are usually accompanied by considerable dissolution of the metals, with the consequence that the quality is always largely reduced. This calls for the introduction of suitable materials (inhibitors) into the solution in contact with the surface of the metals in order to inhibit the corrosion reaction and reduce the corrosion rate and thus protect these metals and alloys from corrosion in such aggressive environments. In the literature [1-9], several reports on the use of different organic compounds as corrosion inhibitors for steel in acidic environments are common, though none has provided a comprehensive answer to the problem. Increased environmental awareness and the need to promote environmentally friendly processes is one of the most important factors of consideration when choosing these organic inhibitors. This is because the negative impact of environmental degradation/pollution is quite devastating and permeates different fields of human endeavour. This has been highlighted by different research groups [10-15].

Corresponding Author: H.K. Idu, Department of Physics, Faculty of Science,
Ebonyi State University, Abakaliki, Ebonyi State, Nigeria.

In general, plant extracts are low-cost and environmental safe materials for application as corrosion inhibitors of metals in different media. Guava (*Psidium guajava* L.), is known to be a tropical fruit which belongs to the Myrtaceae family. The use of *Moringa Oleifera* and *Psidium guajava* leaves extract for various applications, excluding as inhibitors for mild steel has been reported by other authors. However, the use of other plant extracts as inhibitors has been investigated. For instance, (i) Abiola et al [9] worked on the inhibitory properties of *Delonix regia* extracts on the corrosion of aluminium in hydrochloric acid solutions and noted that the inhibition efficiency increased with increasing concentration of the inhibitor but decreased with increase in exposure time. (ii) Okafor et al [2], studied the effect of different parts of *Carica papaya* (leaves (LV), seeds (SD), heart wood (HW) and bark (BK) as eco-friendly and non-toxic mild-steel corrosion inhibitors in H_2SO_4 at temperatures $\leq$ 60°C, employing the gravimetric and gasometric techniques. The authors observed that the inhibition efficiency increased with extracts concentration but decreased with temperature. (iii) Deng and Li [3], reported on the inhibition of Ginkgo leaves extract on the corrosion of steel in HCl and H_2SO_4 solutions and noted that *Ginkgo* leaves extract (GLE) acts as a good inhibitor for steel in HCl and H_2SO_4 media, exhibiting more efficient inhibition in 1.0 M HCl than in 0.5 M H_2SO_4 media.

To the best of our knowledge, this is a novel research; hence this paper provides new information on the possible pathways for application of *Moringa oleifera* and *Psiduim guajava* leaves extract as an environmentally friendly corrosion inhibitor under the specified conditions used in the study. These (*Moringa oleifera* and *Psiduim guajava* leaves extract) environmentally friendly inhibitors could find useful applications in metal surface anodizing, surface coatings and in many industrial applications.

MATERIALS AND METHODS

The materials used were hydrogen tetra-oxosulphate VI solution (H_2SO_4), *Moringa oleifera* leaves, *Psidium guajava* leaves, measuring cylinder (1000 cm^3), volumetric flask (250 cm^3), beakers (1200 cm^3), funnel, spring weighing balance, electronic weighing balance (METTLER TOLEDO model ME204E with an accuracy of 0.0001g), filter cloth, mortar and pestle, hand towel, metre rule, vernier caliper, paper sieve, masking tape, razor blade and nylon thread. The mild steel was obtained from Delta Steel Company Aladja, Delta State, Nigeria. The composition of the mild steel sample was analyzed using Metal Analyzer, Optical Emission Spectrometer.

Material Preparation: The cylindrical samples of diameter 1cm and height of 1.5cm were carefully cut from a long rod of mild steel (total surface area of coupon 6.284 cm^2). The weight of each piece of the coupon was taken and recorded. An abrasive paper was used to remove any millscale and rust stains on the mild steel specimens before they were cleaned with acetone. The samples were then polished. The coupons were degreased by washing them in absolute ethanol, rinsed in acetone and allowed to dry. The dried coupons were stored in moisture free desiccators until required for use. The chemicals and reagents used in this study were of analytical grade and distilled water was used to prepare them.

Preparation of Leaves Extract: The *Moringa oleifera* and *Psidium guajava* leaves used for the study were sourced locally. The leaves extracts were prepared by extracting weighed amount of the fresh leaves of *Moringa oleifera* and *Psidium guajava* for two hours under ambient conditions. After this, it was manually squeezed by pounding with mortar and pestle to obtain corresponding juice extracts without addition of water and then filtered. Further, the solution was filtered and stored securely. The concentrations of the extracts were expressed in (cm^3). The prepared extracts were measured using a measuring cylinder and were later poured into the different 36 beakers used, each beaker measuring 25, 50, 75 and 100 cm^3 respectively, for each of the tested extracts in 0.5M and 1.0M H_2SO_4 environment.

The mild steel rods were cut into cylindrical shapes of 1.5 by 1cm using the hacksaw, to obtain one hundred and forty four coupons. The whole coupons were weighed individually and recorded, using the electronic digital weighing balance. The beakers containing the media were carefully labeled against the medium, that each contained. The 0.5M and 1.0M of H_2SO_4 solution were prepared by dissolving the appropriate amount of H_2SO_4 respectively in the desired volume of distilled water. The beakers were then rinsed with distilled water before use. A total of thirty six (36) beakers were rinsed and left to dry, before the experiment was set up, so as to avoid additional water (mass). The coupons were immersed in the different media by means of a nylon thread hung on a retort stand and tied to the coupons. The four coupons were immersed in each of the beakers and it was ensured that none of the coupons touched one another to avoid crevice and galvanic corrosion.

Weight Loss Method: The sample coupons of mild steel were first weighed using a digital weighing balance, METTLER TOLEDO model ME204E with a least count of

0.0001g, labeled and immersed in the test solutions of acid and base with and without inhibitor. The weight loss of each of the sample coupons were determined and recorded. The determination of weight loss and recording was repeated consistently every 168 hours (7 days) for a period of 672 hours (28 days). Prior to measurement, each coupon was washed in absolute ethanol, rinsed in distilled water, dried in acetone and then weighed, using the procedures given in the literature [16].

RESULTS AND DISCUSSION

Fig. 1 depicts the corrosion rate profile against the exposure time for the coupons in the 0.5M H_2SO_4 environments in the absence of the *Moringa oleifera* and *Psidium guajava* leaves extacts and with the addition of 25 cm^3 of the *Moringa oleifera* and *Psidium guajava* leaves extract.

The variation of the corrosion penetration rate (CPR) with the exposure time was deduced using standard relations from the literature [17-20]. The mathematical computation of CPR is given by the formula contained in the literature as [16,17];

$$CPR = \frac{K\Delta W}{\rho At} \quad (1)$$

where ΔW is the weight loss after the exposure time t, ρ is the density, A is the exposed specimen area and K is a constant with its magnitude depending on the system of units used.

As indicated in Fig. 1, the effect of the inhibitor on corrosion penetration rate is manifested in the plots, in that when the inhibitor (*Moringa oleifera* and *Psidium guajava* leaves extracts) has been included, the plots were reduced compared to that of the control. The decrease of the corrosion profile for the presence of the *Moringa oleifera* leaves extract was more pronounced, with a relative uniform increase up to ≤ 350 hrs and then decreased uniformly thereafter. The decrease in the CPR for the *Moringa oleifera* leaf extract was > 80% (Fig. 1) compared to the control while the *Psidium guajava* leaves extracts exhibited > 50% decrease. This shows that *Moringa oleifera* leaves extracts had better inhibitory effects under that condition in the H_2SO_4 media.

Fig. 2 indicates the corrosion rate profile against the exposure time for the coupons in the 0.5M H_2SO_4 environments in the absence of the *Moringa oleifera* and *Psidium guajava* leaves extracts and with 50 cm^3 of the *Moringa oleifera* and *Psidium guajava* leaves extract included. The results show that the effect of the two inhibitors were quite pronounced on the CPR curves,

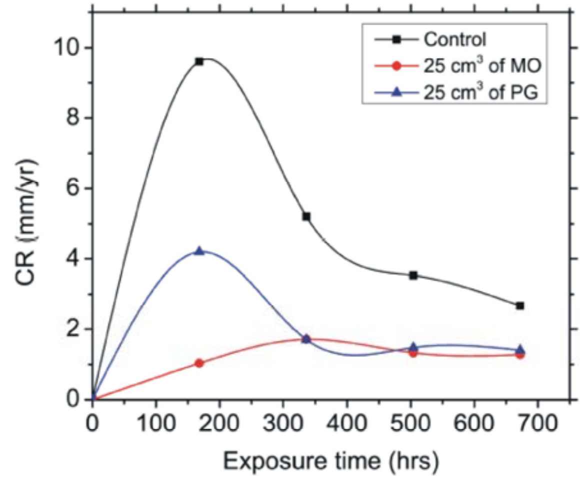

Fig. 1: Plots of corrosion rate against time (25 cm^3 of the inhibitors at 0.5M H_2SO_4)

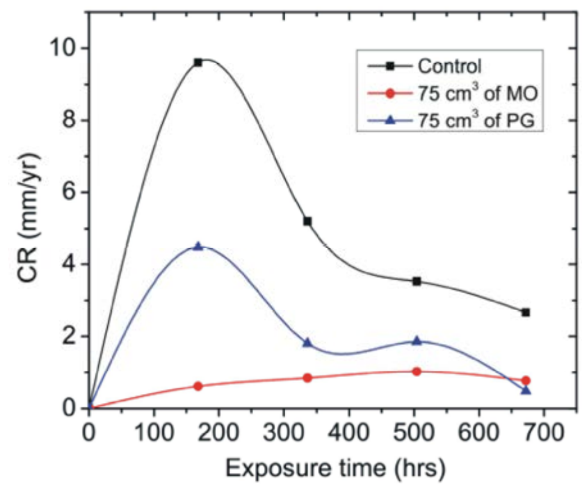

Fig. 2: Plots of corrosion rate against time (50 cm^3 of the inhibitors at 0.5M H_2SO_4)

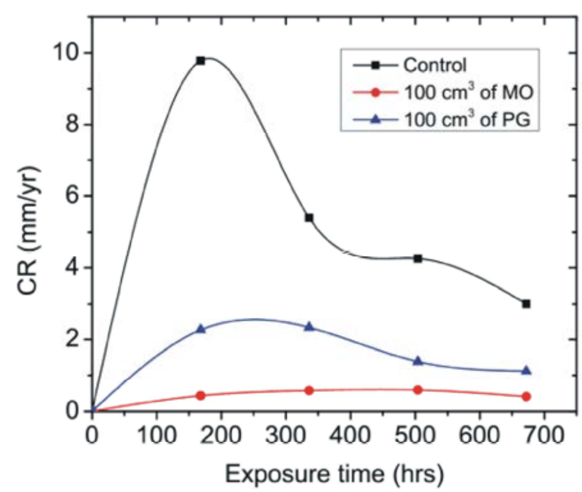

Fig. 3: Plots of corrosion rate against time (75 cm^3 of the inhibitors at 0.5M H_2SO_4)

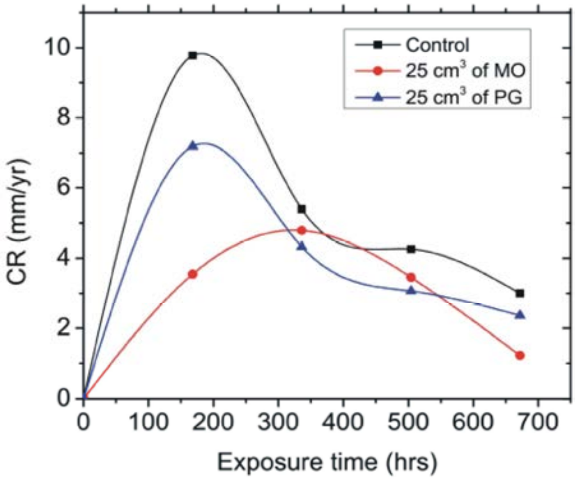

Fig. 4: Plots of corrosion rate against time (100 cm^3 of the inhibitors at 0.5M H_2SO_4)

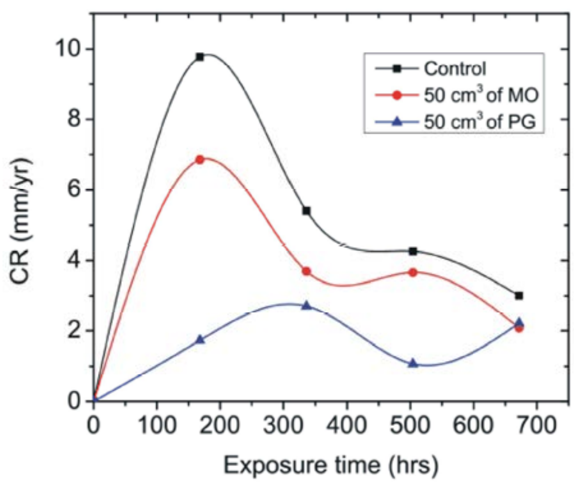

Fig. 5: Plots of corrosion rate against time (50 cm^3 of the inhibitors at 1.0M H_2SO_4)

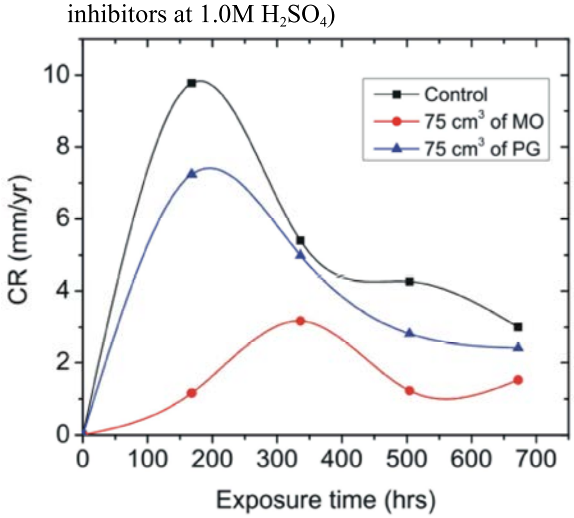

Fig. 6: Plots of corrosion rate against time (75 cm^3 of the inhibitors at 1.0M H_2SO_4)

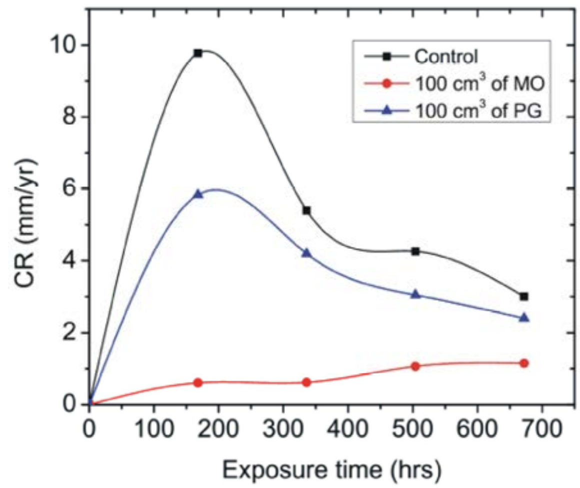

Fig. 7: Plots of corrosion rate against time (100 cm^3 of the inhibitors at 1.0M H_2SO_4).

indicating a clear reduced value compared to the control. However the change was relatively close to when the volume of the inhibitor was 25 cm^3. This behavior observed herein is explained on the basis of the small margin between the two cases. Figs. 3-4, indicates the corrosion rate profile against the exposure time for the coupons in the 0.5M H_2SO_4 environments in the absence of the *Moringa oleifera* and *Psidium guajava* leaves extracts and with 75 and 100 cm^3 of the *Moringa oleifera* and *Psidium guajava* leaves extract included respectively. A decrease in CPR plots was also observed in both cases compared to the control. However, the more drastic decrease was observed in the case of the *Moringa oleifera* leaves extracts at a volume of 100 cm^3. This was attributed to the increased concentration due to increased volume, or to localized uniform inhibitive effects at that condition. This observation is in agreement with the reports of other authors [2].

Figs. 5-7, indicates the corrosion rate profile against the exposure time for the coupons in the 1.0M H_2SO_4 environments in the absence of the *Moringa oleifera* and *Psidium guajava* leaves extracts and with 25 cm^3 to 100 cm^3 of the *Moringa oleifera* and *Psidium guajava* leaves extract included respectively. A close observation of the plots in Figs. 5-8, reveal that the corrosion penetration rates were all marginally decreased at the respective volumes of the inhibitors (*Moringa oleifera* and *Psidium guajava* leaves extract), except at 100 cm^3 in which a significant decrease was observed for the *Moringa oleifera* leaves extract. The decrease of the CPR was also uniform at that volume of *Moringa oleifera* leaves extract. It is possible that this was caused by a uniform adsorption of the formed oxide layer on the metal surface, thus resulting in the decrease of the corrosion at a uniform rate, while enhanced decrease was due to the reason adduced earlier (at 100 cm^3 for 0.5 M).

CONCLUSION

The inhibitory properties of *Moringa oleifera* and *Psidium guajava* leaves extract on the corrosion susceptibility of mild steel in an acidic environment was investigated. The results show a general trend of decreasing corrosion rate with the exposure time for both inhibitors. In particular the decrease was quite exponential at the highest volumes of the inhibitors (*Moringa oleifera* and *Psidium guajava* leaves extract) in both concentrations of the H_2SO_4 media. This study has opened a gateway for further studies on the inhibitory properties of *Moringa oleifera* and *Psidium guajava* leaves extract on the corrosion properties of mild steel in an acidic environment. It is expected that further investigations involving electrochemical studies such as polarization method should throw more light on the mechanistic aspects of the corrosion behaviour of mild steel under such low cost, environmental friendly inhibitors.

ACKNOWLEDGEMENT

The authors would wish to thank the department of Metallurgical and Material Engineering, Enugu State University of Science and Technology (ESUT), the department of Industrial Chemistry, Ebonyi State University, Abakaliki (EBSU), Nigeria for permission to use their facilities and also to Delta Steel Company Aladja, Delta State, Nigeria, for making the mild steel material available.

REFERENCES

1. Rekkab, S., H. Zarrok, R. Salghi, A. Zarrouk, L. Bazzi, B. Hammouti and M. Zougagh, 2012. Green corrosion inhibitor from essential oil of Eucalyptus globulus (Myrtaceae) for C38 steel in sulfuric acid solution, Journal of Materials and Environmental Science, 3(4): 613-627.
2. Okafor, P.C. and E.E. Ebenso, 2007. Inhibitive action of Carica papaya extracts on the corrosion of mild steel in acidic media and their adsorption characteristics, Pigment Resin Technology, 36(3): 134-140.
3. Deng, S. and X. Li, 2012. Inhibition by Ginkgo leaves extract of the corrosion of steel in HCl and H_2SO4 solutions. Corrosion Science, 55: 407-415.
4. Oguzie, E.E., 2008. Evaluation of the inhibitive effect of some plant extracts on the acid corrosion of mild steel, Corrosion Science, 50(11): 2993-2998.
5. Ostovari, A., S.M. Hoseinieh, M. Peikari, S.R. Shadizadeh and S.J. Hashemi, 2009. Corrosion inhibition of mild steel in 1M HCl solution by henna extract: A comparative study of the inhibition by henna and its constituents (Lawsone, Gallic acid, α-d-Glucose and Tannic acid). Corrosion Science, 51(9): 1935-1949.
6. Satapathy, A.K., G. Gunasekaran, S.C. Sahoo, K. Amit and P.V. Rodrigues, 2009. Corrosion inhibition by Justicia gendarussa plant extract in hydrochloric acid solution. Corrosion Science, 51(12): 2848-2856.
7. Raja, P.B. and M.G. Sethuraman, 2008. Atropine sulphate as corrosion inhibitor for mild steel in sulphuric acid medium. Mater. Letts, 62(10): 1602-1604.
8. Negm, N.A., N.G. Kandile, I.A. Aiad and M.A. Mohammad, 2011. New eco-friendly cationic surfactants: Synthesis, characterization and applicability as corrosion inhibitors for carbon steel in 1N HCl. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 391(1): 224-233.
9. Abiola, O.K., N.C. Oforka, E.E. Ebenso and N.M. Nwinuka, 2007. Eco-friendly corrosion inhibitors: the inhibitive action of Delonix Regia extract for the corrosion of aluminium in acidic media. Anti-Corrosion Methods and Materials, 54(4): 219-224.
10. Stern, D.I., M.S. Common and E.B. Barbier, 1996. Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development, World Development, 24(7): 1151-1160.
11. Nwofe, P.A., 2013. Waste Management and Environmental Sustainability: A case Study of Selected Cities in Ebonyi State, Continental Journal of Environmental Sciences, 7(1): 20-28.
12. Nwofe, P.A., 2013. Comparative Analysis of Domestic Energy Use in Nigeria- A Review, Continental Journal of Renewable Energy, 4(1): 7-17.
13. Nwofe, P.A., 2013. Determination of the Generation Rate of Solid Waste in Abakaliki Metroplolis, Ebonyi State, Nigeria, Continental Journal of Environmental Sciences, 7(2): 1-3.

14. Nwofe, P.A., 2014. Waste Resources and Climate Change: Implications and Mitigation, International Journal of Science and Research, 3(9): 1602-1606.
15. Nwofe, P.A., 2015. Management and Disposal of Municipal Solid Wastes in Abakaliki Metropolis Ebonyi State, Nigeria, International Journal of Scientific Research in Environmental Sciences, 3(3): 0107-0118.
16. Iloamaeke, I.M., T.U. Onuegbu, V.I.E. Ajiwe and U.C. Umeobika, 2012. Corrosion Inhibition Of Mild Steel By Pterocarpus Soyauxi Leaves Extract In Hcl Medium, International Journal of Plant, Animal and Environmental Sciences, 2(3): 22-28.
17. Ekuma, C.E. and N.E. Idenyi, 2007. The Inhibition Characteristics of Brine on the Corrosion Susceptibility of Al-Zn Alloy Systems, Information Technology Journal, 7(2): 237-241.
18. Idenyi, N.E., P.A. Nwofe, P.E. Agbo, B.J. Ifeanyichukwu and C.O. Ozibo, 2015. Effects of Manganese Addition on the Corrosion Behaviour of Aluminium Alloys in Different Media, Asian Journal of Applied Sciences, 3(5): 514-519.
19. Bentiss, F., M. Lagrenee, M. Traisnel and J.C. Hornez, 1999. The corrosion inhibition of mild steel in acidic media by a new triazole derivative, Corrosion Science, 41(4): 789-803.
20. Bentiss, F., M. Traisnel and M. Lagrenee, 2000. The substituted 1, 3, 4-oxadiazoles: a new class of corrosion inhibitors of mild steel in acidic media, Corrosion Science, 42(1): 127-146.