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# Investigations on the Inhibitory Properties of *Moringa Oleifera* and *Psidium guajava* Leaves Extract on the Corrosion Susceptibility of Mild Steel

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**Abstract:** This paper reports on the inhibitive properties of *Moringa Oleifera* and Psidium *guajava* Leaves Extract on the Corrosion Susceptibility of Mild Steel in an alkaline environment, in particular sodium hydroxide (NaOH). Varying volumes of the leaves extract of *Moringa oleifera* (MO) and *Psidium guajava* (PG) in the range of 25 to 100 $cm^3$ were used for the investigations. The mild steel were cast into rods; which were later machined and subsequently cut into coupons averaging a total surface area of 6.284 $cm^2$. The samples were weighed and immersed into beakers containing 0.5M and 1.0M of sodium hydroxide and the different volumes of the *Moringa oleifera* (MO) and *Psidium guajava* (PG) were introduced in the respective beakers consequentially. The set up were allowed to stand for 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). In particular, the corrosion penetration rate was found to be decreased by >60% in the 0.5M NaOH and by >80% in the 1.0M NaOH at the different volumes of both inhibitors used in the study. From the findings, it was concluded that the concentration of 1.0M NaOH is the optimum conditions for reduced corrosion rate of mild steel in an alkaline media in the presence of the inhibitors.

**Key words:** Alkaline · Corrosion susceptibility · Inhibitor · Mild steel

## INTRODUCTION

Corrosion is a natural phenomenon and its attack on metals has serious negative consequences. In the literature, some of the major causes of corrosion of metals is widely believed to be caused from their temporal existence in the state of higher energy level due to the absorbed energy, in the course of extraction from their ores which makes them quite unstable, coupled with the fact that certain environments enhance their combination chemically with elements in their environment to form compounds and return to their natural stable ore state with accompanying reduction in the free energy of the system [1, 2]. Guava (*Psidium guajava* L.), is a tropical fruit which belongs to the Myrtaceae family. The use of *Moringa Oleifera* and *Psidium guajava* leaves extract for various applications has been widely reported by various research groups. For instance, (i) Deguchi and Miyazaki [3] noted that *Psidium guajava* Linn. (Guava) is used not only as food but also as folk medicine in subtropical areas around the world due to its pharmacologic activities. In particular, the leaf extract of guava has traditionally been used for the treatment of diabetes in East Asia and other countries (ii) the leaves and fruits of guava have been reported to have an anti-diarrheal, hypoglycemic, lipid lowering, anti-bacterial in addition to antioxidant activities [4-7], (iii) as inhibitors in Quorum sensing (QS) (a process usually mediated through small molecules known as autoinducers (AI) that allow bacteria to respond and adjust according to the cell population density by altering the expression of multitudinous genes) [8], (iv) and as antimicrobial and antibacterial agents [9, 10]. In the literature, there are several reports on the use of different inhibitors to reduce corrosion susceptibility of different metals, including mild steel in different media [11-15]. However, there are few reports on

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the use of *Moringa oleifera* and *Psiduim guajava* leaves extract as inhibitors on the corrosion susceptibility of mild steel; hence this research is novel in contributing the knowledge in the area of corrosion of metals.

## MATERIALS AND METHODS

The materials used for the experiment were sodium hydroxide solution (NaOH), *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 used for this study 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 NaOH 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 NaOH solution were prepared by dissolving the appropriate amount of NaOH 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.

## RESULTS AND DISCUSSION

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

The variation of the corrosion penetration rate with the exposure time was computed using standard relations from the literature. The corrosion penetration rate (CPR) as the consequence of the physiochemical interactions mostly expressed in mm/year is an important corrosion monitoring index that gives reliable information on the degree of corrosion in a given material independent of the environment. The mathematical computation of CPR is based on the formula [16, 17];

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

In equation 1, 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. In general, it has been argued by various authors that this estimation is suitable only for uniform corrosion and becomes somewhat erratic with local instability [18].

As indicated in Fig. 1, the effect of the inhibitor on corrosion penetration rate is glaringly clear in the plots, indicating that when the inhibitor (*Moringa oleifera* and

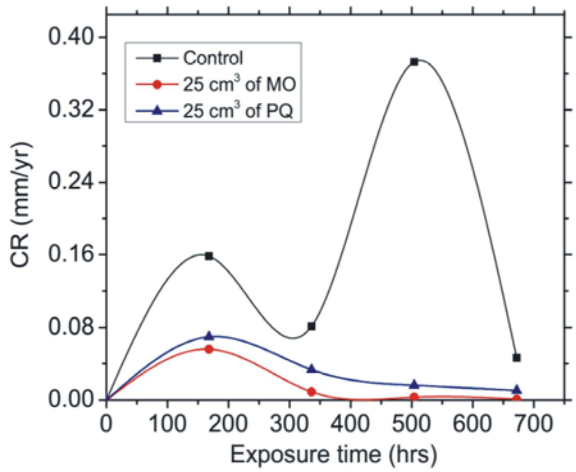


Fig. 1: Plots of corrosion rate against time (25 $cm^3$ of the inhibitors at 0.5M NaOH).

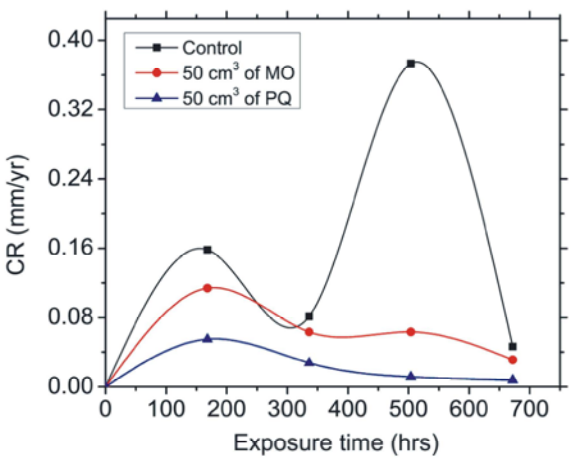


Fig. 2: Plots of corrosion rate against time (50 $cm^3$ of the inhibitors at 0.5M NaOH).

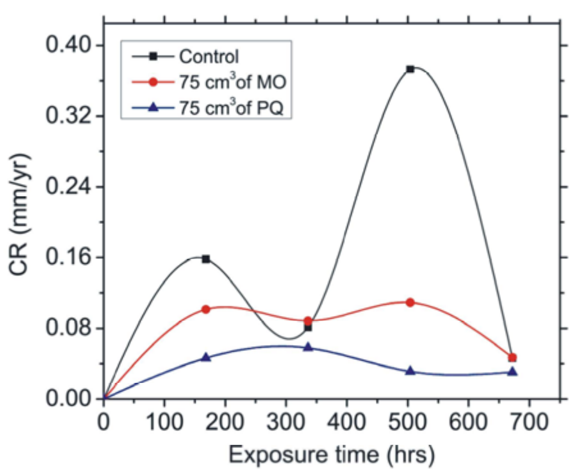


Fig. 3: Plots of corrosion rate against time (75 $cm^3$ of the inhibitors at 0.5M NaOH).

*Psidium guajava* leaves extracts) has been included, the plots were reduced by >60% of the control. The decrease of the corrosion profile for the presence of the *Moringa oleifera* leaves extract was more pronounced especially at exposure time >300 hrs, indicatinag the effectiveness of the *Moringa oleifera* leaf extract compared to the *Psidium guajava* leaves extracts in that environment.

Fig. 2 gives the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH 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 relatively the same in that the profile for the corrosion penetration rate increased in both cases up to an exposure time of 168 hrs and then decreased thereafter. However, at this particular volume of the inhibitors, the decrease of the corrosion penetration rate of the *Psiduim guajava* leaves extracts was more pronounced compared to that of the *Moringa oleifera* leaf extracts. This behavior observed herein is explained on the basis of the fact that with the increasing leaves extract content, the amount of these precipitates increases, thus limiting the corrosion rate. However, the more pronounced decrease observed in the case of the *Psidium guajava* leaves extracts could be due to a localized uniform inhibitive effects compared to the former. According to the literature, Shingh *et al*. [19, 20] reported on the inhibitive properties of *Moringa oleifera* fruit extract on the corrosion of mild steel in hydrochloric acid and noted that the inhibition was found to increase with increasing concentration of the extract. The authors also noted that the inhibition occurred via adsorption of the inhibitor molecules on the mild steel surface, obeying the Langmuir adsorption isotherm in their observations.

Fig. 3 indicates the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH environments in the absence of the *Moringa oleifera* and *Psidium guajava* leaves extracts and with 75 $cm^3$ of the *Moringa oleifera* and *Psidium guajava* leaves extract included. This observation as indicated in Fig. 3, show that at 0.5M of NaOH concentration with different volumes (75 $cm^3$) of the inhibitor introduced, the decrease in the corrosion penetration rate was relatively the same to that when 25$cm^3$ was introduced. This could be due to the sparingly marginal difference in the range of the volumes of the inhibitors used.

Fig. 4 show the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH environments in the absence of the *Moringa oleifera* and

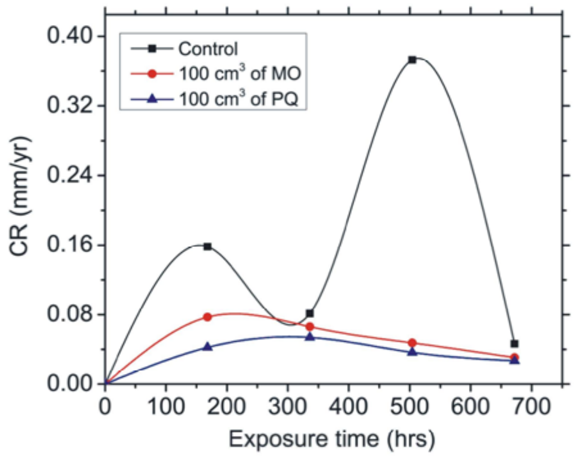


Fig. 4: Plots of corrosion rate against time (100 cm$^3$ of the inhibitors at 0.5M NaOH).

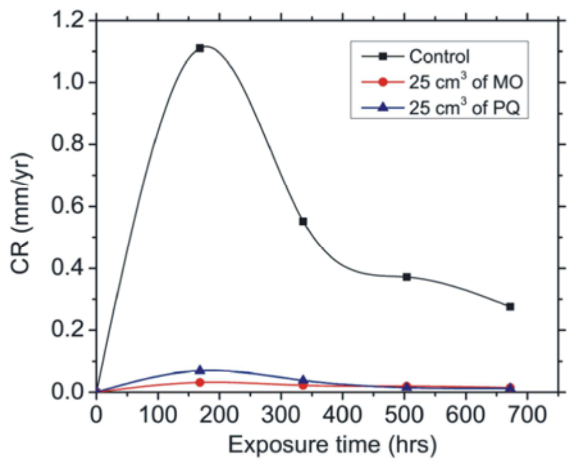


Fig. 5: Plots of corrosion rate against time (25 cm$^3$ of the inhibitors at 1.0M NaOH).

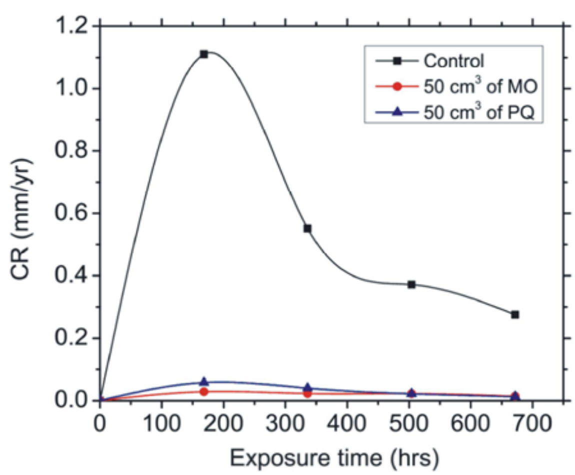


Fig. 6: Plots of corrosion rate against time (50 cm$^3$ of the inhibitors at 1.0M NaOH).

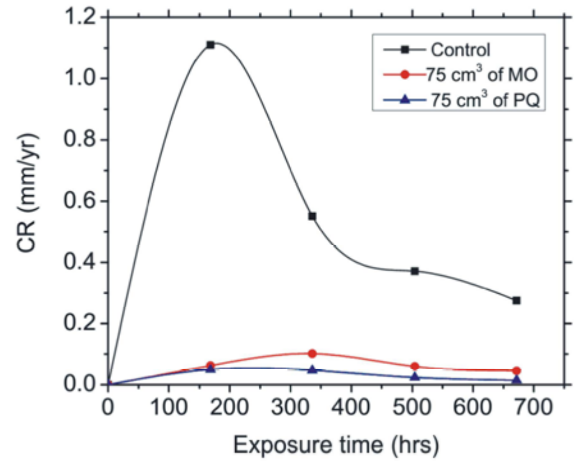


Fig. 7: Plots of corrosion rate against time (75 cm$^3$ of the inhibitors at 1.0M NaOH).

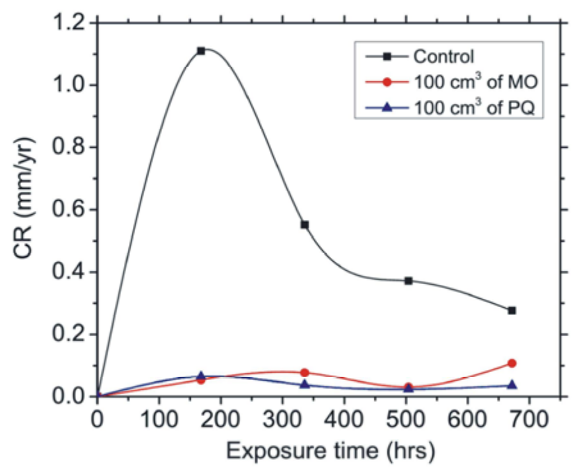


Fig. 8: Plots of corrosion rate against time (100 cm$^3$ of the inhibitors at 1.0M NaOH).

*Psidium guajava* leaves extracts and with 100 cm$^3$ of the *Moringa oleifera* and *Psidium guajava* leaves extract included. As indicated in the plots, the corrosion rate (in the presence of inhibitor) exhibited a uniform increase up to an exposure time of 168 hrs and then decreased uniformly thereafter. This behavior indicates that at the volume of 100 cm$^3$ of both inhibitors, a uniform corrosion was achieved.

Figs. 5-8, indicates the corrosion rate profile against the exposure time for the coupons in the 1.0M NaOH 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. A close observation of the plots in Figs. 5-8, reveal that the corrosion penetration rates were all decreased by >80% at the respective volumes of the inhibitors (*Moringa oleifera* and *Psidium guajava* leaves extract). In particular, the decrease was more pronounced at volumes of the inhibitors $\leq$ 50 $cm^3$ as the values were relatively close to zero for exposure time $\geq$300 hrs. This behavior was attributed to uniform corrosion attack at that range, or to the uniform adsorption of the formed oxide layer on the metal surface, thus resulting in the decrease of the corrosion at a uniform rate. These observations strongly suggest that the optimized conditions for decreased corrosion rate are within the range 25 to 50 $cm^3$ of both inhibitors at 1.0M sodium hydroxide environment.

## CONCLUSIONS

In this study, the inhibitory properties of *Moringa oleifera* and *Psidium guajava* leaves extract on the corrosion susceptibility of mild steel in an alkaline environment are 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 higher concentration independent of the volumes of the inhibitors (*Moringa oleifera* and *Psidium guajava* leaves extract). At 1.0M concentration of the NaOH, the decrease was more pronounced at volumes of the inhibitors $\leq$50 $cm^3$ as the values were relatively close to zero for exposure time $\geq$300 hrs. The study further concludes that this observation is an indication that these conditions can be used to obtain minimum corrosion effect on mild steel in an alkaline environment under the influence of such low cost inhibitors.

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## REFERENCES

1. Sastri, V. S., 1998. Corrosion inhibitors: principles and applications. Wiley, pp: 153.
2. Hinton, B.R.W., 1992. Corrosion inhibition with rare earth metal salts. J. Alloys & Compounds, 180(1): 15-25.
3. Deguchi, Y. and K. Miyazaki, 2010. Anti-hyperglycemic and anti-hyperlipidemic effects of guava leaf extract. Nutr. Metab., 7(9): 1-10.
4. Hung-Hui, C., W. Po-Hua, L. Diana, P. Yun-Chieh and W. Ming-Chang, 2011. Hepatoprotective Effect of Guava (Psidium guajava L.) Leaf Extracts on Ethanol-Induced Injury on Clone 9 Rat Liver Cells. Food and Nutrition Sciences, 2(9): Article ID: 8379.
5. Abreu, P.R.C., M.C. Almeida, R.M. Bernardo, L.C. Bernardo, L.C. Brito, E.A.C. Garcia and M. Bernardo-Filho, 2006. Guava extract (Psidium guajava) alters the labelling of blood constituents with technetium-99m. Journal of Zhejiang University Science B, 7(6): 429-435.
6. Kong, F., S. Yu, F. Zeng and X. Wu, 2015. Preparation of Antioxidant and Evaluation of the Antioxidant Activities of Antioxidants Extracted From Sugarcane Products. Journal of Food and Nutrition Research, 3(7): 458-463.
7. Kong, F., S. Yu, Z. Feng and X. Wu, 2015. Optimization of ultrasonic-assisted extraction of antioxidant compounds from Guava (Psidium guajava L.) leaves using response surface methodology. Pharmacogn Mag., 11(43): 463-469.
8. Ghosh, R., B.K. Tiwary, A. Kumar and R. Chakraborty, 2014. Guava Leaf Extract Inhibits Quorum-Sensing and Chromobacterium violaceum Induced Lysis of Human Hepatoma Cells: Whole Transcriptome Analysis Reveals Differential Gene Expression. PLoS ONE 9(9): e107703.
9. Mehta, V.V., G. Rajesh, A. Rao, R. Shenoy and B.H. Mithun Pai, 2014. Antimicrobial Efficacy of Punica granatum mesocarp, Nelumbo nucifera Leaf, Psidium guajava Leaf and Coffea Canephora Extract on Common Oral Pathogens: An In-vitro Study. J. Clin. Diagn. Res, 8(7): ZC65-ZC68.
10. Mahfuzul Hoque, M.D., M.L. Bari, Y. Inatsu, V.K. Juneja and S. Kawamoto, 2007. Antibacterial activity of guava (Psidium guajava L.) and neem (Azadirachta indica A. Juss.) extracts against foodborne pathogens and spoilage bacteria. Foodborne Pathogens and Disease, 4(4): 481-488.
11. Raja, P.B. and M.G. Sethuraman, 2008. Natural products as corrosion inhibitor for metals in corrosive media—a review. Mater. Letts., 62(1): 113-116.
12. Abdallah, M., 2002. Rhodanine azosulpha drugs as corrosion, inhibitors for corrosion of 304 stainless steel in hydrochloric acid solution. Corrosion Science, 44(4): 717-728.

13. 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.
14. 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.
15. Ashassi-Sorkhabi, H., M.R. Majidi and K. Seyyedi, 2004. Investigation of inhibition effect of some amino acids against steel corrosion in HCl solution. Appl. Surf. Sci., 225(1): 176-185.
16. 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.
17. Vuelvas, S., S. Valdez and J.G. Gonzalez-Rodriguez, 2012. Effect of Mg and Sn Addition on the Corrosion Behavior of an Al-Mn Alloy in 0.5 M $H_2SO_4$. Int. J. Electrochem. Sci., 7: 4171-4181.
18. Chandler, A.K., 1985. Marine and Offshore Corrosion, Betterworth and Co. Publishers Ltd, pp: 89.
19. Singh, A., V.K. Singh and M.A. Quraishi, 2010. Effect of fruit extracts of some environmentally benign green corrosion inhibitors on corrosion of mild steel in hydrochloric acid solution. J. Mater. Environ. Sci, 1(3): 162-174.
20. Singh, A., I. Ahamad, D.K. Yadav, V.K. Singh and M.A. Quraishi, 2012. The effect of environmentally benign fruit extract of shahjan (Moringa Oleifera) on the corrosion of mild steel in hydrochloric acid solution. Chemical Engineering Communications, 199(1): 63-77.