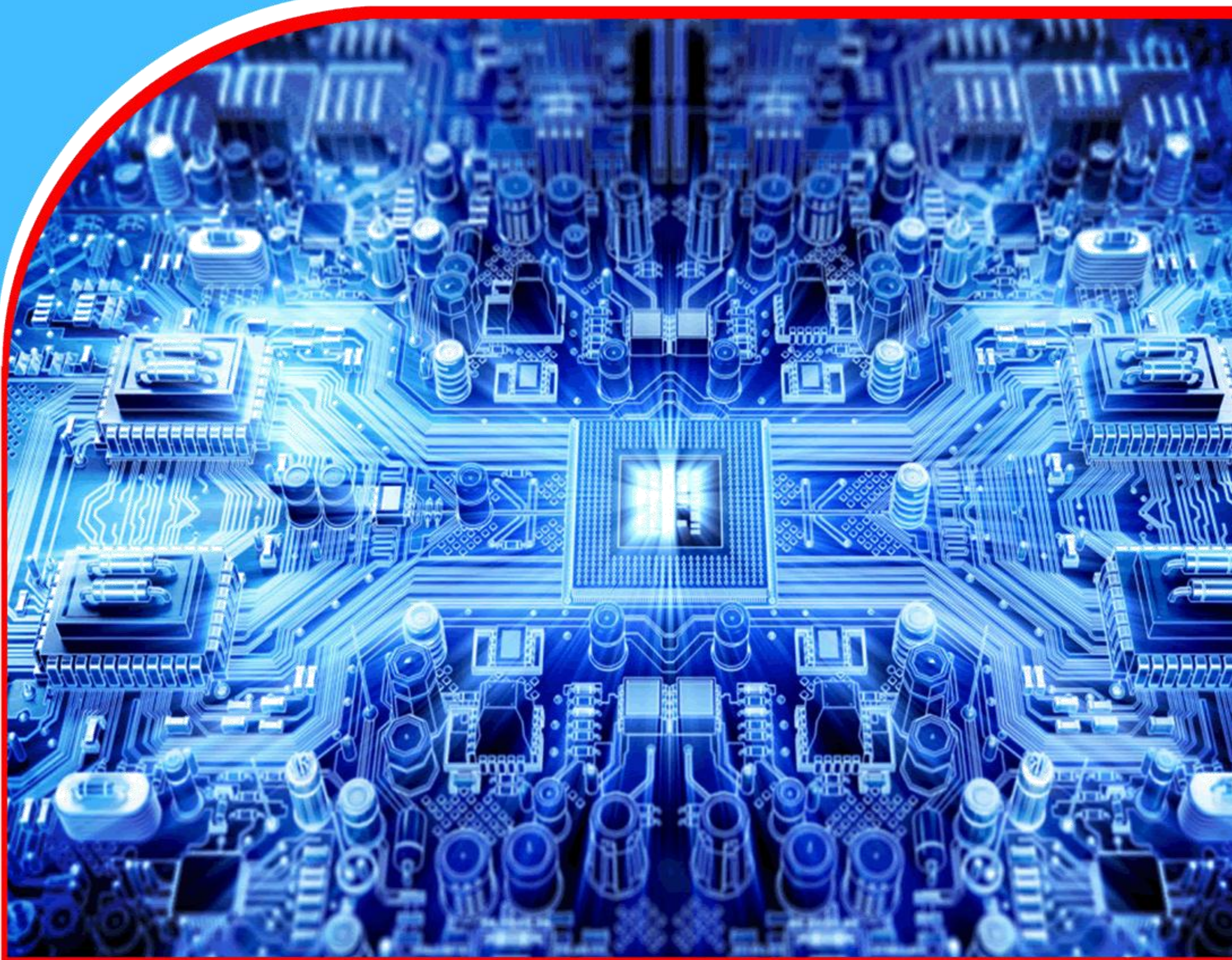
American Journal of
Computing and Engineering
(AJCE)



Evaluation of Adansonia Digitata (Baobab) Leaf and Root Extracts as Inhibitor on Dual Phase Steel (DPS) in 0.3M H_2SO_4

Dongo E Isaac, Momoh I Monday, and Banabars A Abel

AJPO

American Journal of Computing and Engineering
ISSN 2790-5586 (Online)
Vol.5, Issue 2, pp 15 – 23, 2022
www.ajpojournals.org

Evaluation of Adansonia Digitata (Baobab) Leaf and Root Extracts as Inhibitor on Dual Phase Steel (DPS) in 0.3M H_2SO_4

Dongo E Isaac[1], Momoh I Monday[2], and Banabars A Abel[3]

[1]Department of Metallurgical & Materials Engineering, Kogi State Polytechnic,Lokoja, Nigeria

[2]Department of Foundry Engineering Technology, Kogi State Polytechnic,Lokoja, Nigeria

[3]Department of Materials & Metallurgical Engineering, Nigerian Army University Biu, Nigeria

Corresponding Author's Email: isaacdongo@gmail.com

Abstract

Purpose: In this work, the effect of indigenously sourced baobab leaf and root was experimented on the substrate of inter-critically developed dual phase steel in 0.3M H_2SO_4.

Methodology: Standard techniques were adopted in carrying out the development and the corrosion experiments. Weight loss method was adopted and the corrosion rate eventually estimated following a standard route.

Findings: From the results, it was observed that inter-critical heat treatment technique can be used to develop dual phase steel with a competing properties with the conventional dual phase steel. The use of baobab leaf and root extracts was also observed to serve as an organic inhibitor for dual phase steel having observed that the percentage inhibition efficiency (% IE) increases with increase in the soaking temperature of the developed DPS.

Recommendation: The use of baobab leaf and root is thus recommended as alternative organic inhibitor to impede corrosion rate in DPS.

Keywords: *Baobab, Dual Phase Steel, Inter-critical treatment, Inhibition Efficiency*

1.0 INTRODUCTION

Corrosion has been a major issue affecting metallic materials and their alloys thereby making their structural integrity questionable over time due to its effect on durability, strength and lifespan. Inspite of these limitations, metallic materials are still the most widely used group of materials particularly in mechanical engineering and its allied industries (Bauchweishaija, 2009). Corrosion, on the other hand, is the gradual destruction of materials resulting from exposure and interaction with the environment. One of the popular approaches of reducing corrosion is the use of substances called corrosion inhibitors. These inhibitor molecules consist of heterocyclic compounds with polar functional groups (such as N, S, O, and P) and conjugated double bonds with different aromatic systems.

Corrosion attack can be prevented by various methods such as materials improvement, combination of production fluids, process control, and chemical inhibition to mention but a few. Among these methods, the implementation of corrosion inhibition is the most excellent approach to avoid disastrous destruction of metals and alloys in corrosive media. The use of corrosion inhibitors is the most economical and convenient technique to control corrosive attack on metals. Corrosion inhibitors are chemicals either synthetic or natural which, when added in small amounts to an environment, decrease the rate of attack by the environment on metals. A number of synthetic compounds are known to be applicable as good corrosion inhibitors for metals (Thompson et al., 2007; Quraishi et al., 2012; Ebenso et al., 2012). Corrosion inhibitors are also used in acid solutions to prevent unexpected metal dissolution and acid consumption (Abdulrahman et al., 2011; Abdulrahman & Ismail, 2011). The known hazardous effect of most synthetic corrosion inhibitors have motivated scientists to use naturally occurring products as corrosion inhibitors as they are inexpensive, readily available and renewable sources of materials, environmentally friendly and ecologically acceptable (Asipita et al., 2014; Abdel-Gaber et al., 2012; Abdulrahman & Ismail, 2014). Corrosion phenomena, control and prevention are scientific issues that must be addressed daily as long as there is increasing need for metallic materials in all facets of technological development (Loto et al., 2011). However, the problem of finding an inhibitor that has little or no impact on the environment has attracted numerous interests from researchers in recent times. Green corrosion inhibitors are biodegradable and do not contain toxic compounds. Leaves have been used as eco-friendly corrosion inhibitors.

Dual phase steel (DPS) is one of the major engineering materials, which is extensively used in chemical and allied industries for handling of acid, alkali and salt solutions. But its susceptibility to corrosion in humid air and its very high dissolution rate in acid medium are the major obstacles for its use on larger scale (Sachin et al., 2007). In steel and ferrous alloy industries, hydrochloric acid and sulphuric acid are generally used as pickling agents to remove the oxide scales (Petro & Murthy, 2017). The inhibition of the corrosion of steel is of great importance and that can be done in many ways, among which the use of organic compounds as corrosion inhibitors is the most popular one (Quaraishi & Jamal, 2000). Usually, inhibitors protect the metal by adsorbing on the surface and retard metal corrosion in aggressive media. So selecting the appropriate inhibitor for a particular metal is very important. A variety of nitrogen containing organic compounds has been tried as corrosion inhibitors for mild steel in acid media. So most of the excellent acid inhibitors are organic compounds containing nitrogen, sulphur, oxygen and phosphorous in their functional groups (Ebenso, 2003).

American Journal of Computing and Engineering
ISSN 2790-5586 (Online)
Vol.5, Issue 2, pp 15 – 23, 2022
www.ajpojournals.org

This work focuses on the use of extracts from *Adansoniadigitata* (leaf and root) which is known to belong to the family Bombaceae and is known generally as the African baobab, to inhibit corrosion of DPS in H_2SO_4 solution. The coupons were subjected to the test medium at various concentration intervals and corrosion rates (C.R) determined through weight loss technique.

2.0 EXPERIMETAL PROCEDURE

2.1 Preparation of *Adansoniadigitata* (baobab) Leaves and Root Extract Solution

The *Adansoniadigitata* (baobab) leaves and root were sourced from Kogi State, Nigeria. Fresh leaves and root were collected, washed and dried at room temperature for three days and was subsequently oven-dried to remove residual moisture. The extraction was done using the aqueous solvent method (Arockia et al., 2016). The dried leaves and root samples were pulverized to fine powder, and were further sieved to homogeneous particles. The inhibitor solutions were prepared bydissolving 300g homogeneous leaves, and root extracts into 500ml of ethanol and left for 48hrsat room condition and thereafter filtered. The filtered solutions were further concentrated by using a Rotary Vacuum Evaporator for 4 hours. The 30 ml solutions from leaf and root extracts were collected and kept in achiller to keep it fresh and prevent denaturingat a controlled temperature of 4^oC.

2.2 Development of Dual Phase Steel (DPS)

Medium carbon low alloy steel (MCLA) with known chemistry as shown in Table 1 was sourced and treated. Figure 1 shows the inter-critical heat-treatment procedures used for the development of the dual phase structures in the medium carbon low alloy steel. The specimens were initially subjected to normalizing treatment to annul the thermal and mechanical history of the steel induced in the course of machining (Momoh & Alaneme, 2013). The normalizing treatment was carried out at isothermal temperature of 870°C for 60 minutes in a muffle furnace and then cooled in air. Samples are set aside as reference (other specimens were also labeledas B1, B2 and B3). Inter-critical treatment was thereafter carried out on the remaining samples isothermally at 770^0C temperature over holding times of 15 minutes for sample B1, 30 minutes for sample B2 and 45 minutes for sample B3. At the end of every stage, the samples were quenched in warm water – of 37^0C – in order to avoid quench cracks.

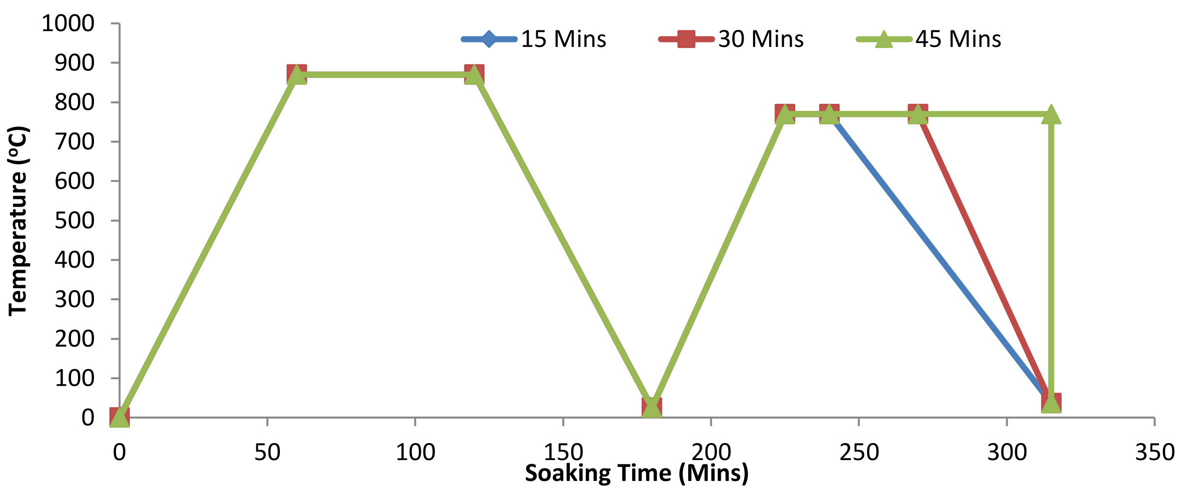


Figure 1: Development of dual phase steel

Table 1: Spectrometric analysis of medium carbon steel used to develop DPS

Elements	**C**	**Si**	**S**	**P**	**Mn**	**Ni**	**Cr**
Composition	0.3300	0.1740	0.0499	0.0341	0.8225	0.0911	0.0585
Elements	**Mo**	**V**	**Cu**	**W**	**As**	**Sn**	**Co**
Composition	0.00180	0.0029	0.3031	0.0003	0.0060	0.0230	0.0094
Elements	**Al**	**Pb**	**Ca**	**Zn**	**Fe**		
Composition	0.0019	-0.0006	0.0002	0.0037	Bal.		

2.3 Preparation of Test Media and Solution Extracts

The Hydrogen tetra oxo sulphate VI acid (H_2SO_4) was diluted with ultrapure water to get a concentration of 0.3M and at ratio 1:10, 25 ml of H_2SO_4 was added slowly in the 250 ml of ultra-pure water (Milli-Q, Millipore)in a beakers for each sample of developed DPS. Then *Adansonia-digitata* (baobab) leaves root inhibitor extracts were added

2.4 Corrosion Experiment

The corrosion test was investigated in 0.3M H_2SO_4solutions which were prepared following standard procedures. The specimen for the test was sectioned to cylindrical configuration, mechanically polished with emery papers. The samples were degreased and then rinsed in distilled water before immersion in the prepared still solutions. The results were evaluated on two days intervals. The corrosion rate and mass loss was evaluated in accordance to ASTM G-1 and G-4 standard using the relation.

$$C.R = \frac{W \times K}{D \times TSA \times T}$$

Where W = Weight loss measured in g

K = Constant factor which depends on the unit of corrosion rate.

D = Metal density measured in g/cm^3

TSA = Total surface area exposed to corrosion measured in cm^2

T = Exposure time in hour and

C.R = Corrosion rate in mmy

3.0 RESULTS AND DISCUSSION

3.1 Effect of Inter-critical Treatment on the Microstructure

Plate 1(Sample B1) shows the micrographs of the normalized structure that produced pearlite which is an equilibrium structure that can scarcely undergo further phase change during the inter-critical treatment until a prolonged heating at the inter-critical temperature region coalescence of the cementite in the pearlitic structure (Ghosh et al, 2004) leading to the commencement of ($\alpha + \gamma$) transformation from the coalescence of the cementite in the initial microstructure. Plates 2 – 4 are micrographs showing the microstructural evolution that occurs during inter-critical treatment. It confirms that inter-critical treatment develops microstructures that exhibited micro-duplex

American Journal of Computing and Engineering
ISSN 2790-5586 (Online)
Vol.5, Issue 2, pp 15 – 23, 2022

features consisting of soft and ductile ferritic (grey) zone combined with hard and brittle martensitic (dark – formerly austenitic) zone. A homogenized structure of ferrite and martensite is achieved with much longer soaking time at various phase volume percentages (Alaneme, 2010).

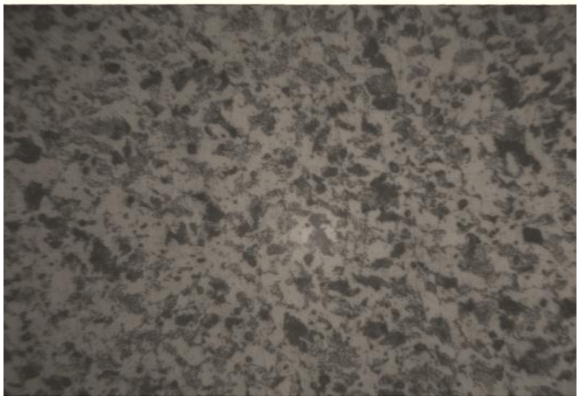


Plate 1: Microstructure of specimen B1 treated at 870^0C/air cool (400X)

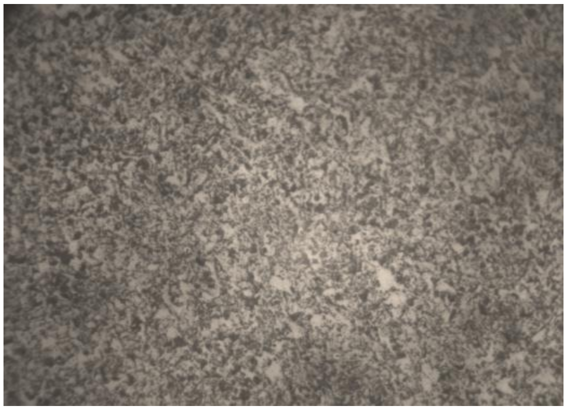


Plate 2: Microstructure of specimen N treated at 870^0C/air cool/770^0C/15mins/Quenched in warm water (400X)

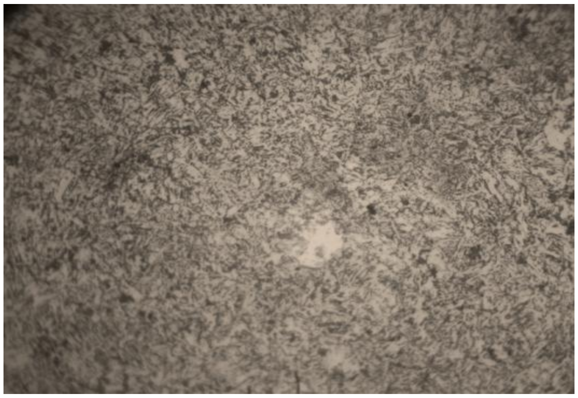


Plate 3: Microstructure of specimen B2 treated at 870^0C/air cool/770^0C/30mins/Quenched in warm water (400X)

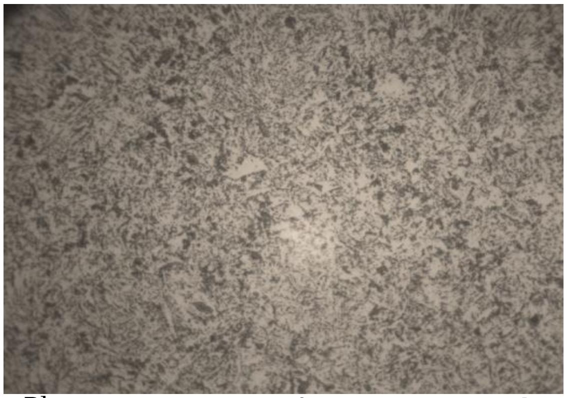


Plate 4: Microstructure of specimen B3 treated at 870^0C/air cool/770^0C/60mins/Quenched in warm water (400X)

3.2 Phytochemical Examination

The phytochemical screening of *baobab* root and leave extractswas carried out using standard procedure (Yuli *et al.*, 2014). The *Adansoniadigitata* (baobab) extracts (leaf and root) characterization using FT-IR, was to determine organic and inorganic compounds functional group present. The summary of the phytochemical analysis of the baobab constituents in Table 2 where it shows that the plant constituents proved positive to the presence of corrosion resistance organic agents (e.g. saponin, tannins, steroid and flavonoids). Besides, the presences of tannin in *Adansoniadigitata* (baobab) extracts (leaf and root) extract show their effectiveness as corrosion inhibitors. Tannin forms complex compounds with Fe (III) on the metal surface (Sachinet al., 2009). While the presence of saponin and flavonoid provided high metal complex affinity that is responsible for effective corrosion inhibitor performance. That is, the presence of saponin and flavonoid provided strong adsorption molecules of the *Adansoniadigitata* (baobab) extracts (leaf

American Journal of Computing and Engineering
ISSN 2790-5586 (Online)
Vol.5, Issue 2, pp 15 – 23, 2022
www.ajpojournals.org

and root) on the mild steel as well as 2101 stainless steel surface, which contributed to the efficiency of the inhibitors possibly due to being a cyclic compounds (Helenet al., 2013).

Table 2: Qualitative phytochemical analysis of *Adansoniadigitata* (baobab) leave and root (Methanol)

Compound	Leave	Root
Alkaloid	+	+
Phenol	+	+
Tannins	+	+
Saponins	+	+
Flavonoids	+	+
Steroids	+	+
Reducing Sugar	+	+

3.3 Effect of Inhibitor on Corrosion Rate

The corrosion rate and mass loss of the developed DPS in H_2SO_4 solution represented in figure l and 2. Observation indicates that the corrosion rate of the inhibited developed DPS is at a close proximity for either of the baobab part (i.e leaf and root) and follows the same trend with the normalized sample. The corrosion behavior and mass loss trends show that sample B3 and D3 possesses better corrosion resistance than the normalized sample in 0.3M H_2SO_4 medium. The sinusoidal trend of the mass loss and corrosion behavior shows the formation of passive film over the surface of the specimen which prevent it from the attack of the solution. This trend sinusoidally decreases as a function of exposure time in the medium.

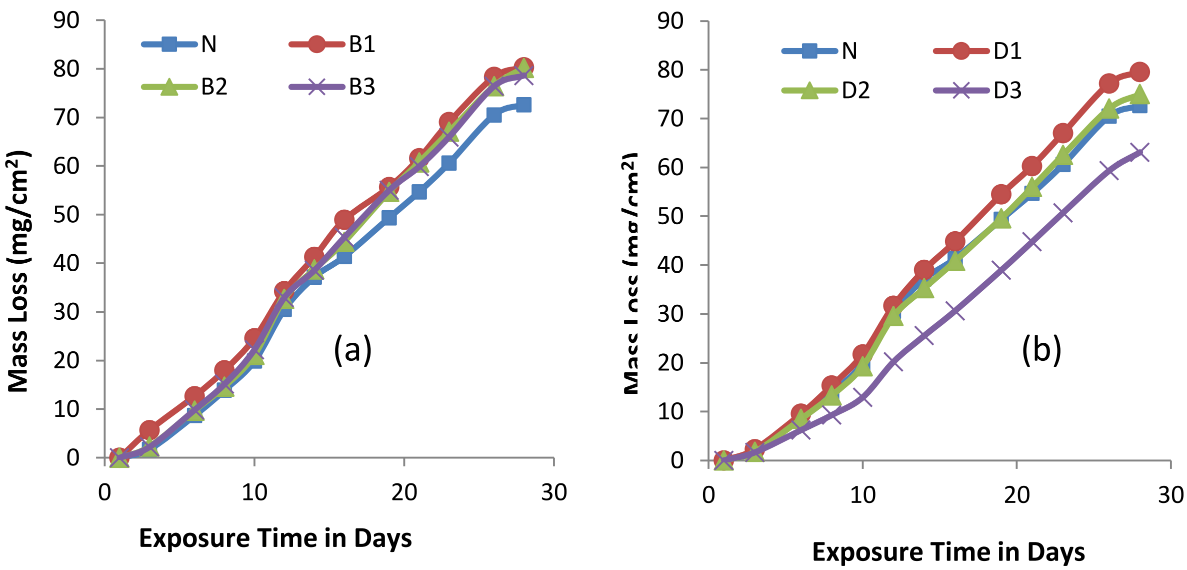


Figure 1: Variation of mass loss of Inhibited DPS with (a) baobab leaf and (b) baobab root in 0.3M H_2SO_4

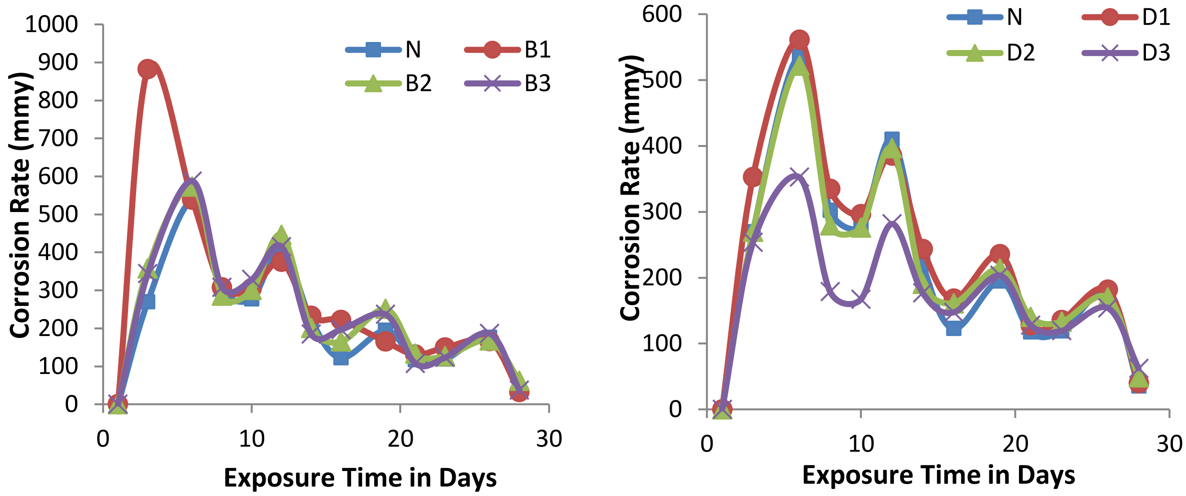


Figure 2: Variation of corrosion rate of Inhibited DPS with (a) baobab leaf and (b) baobab root in 0.3M H_2SO_4

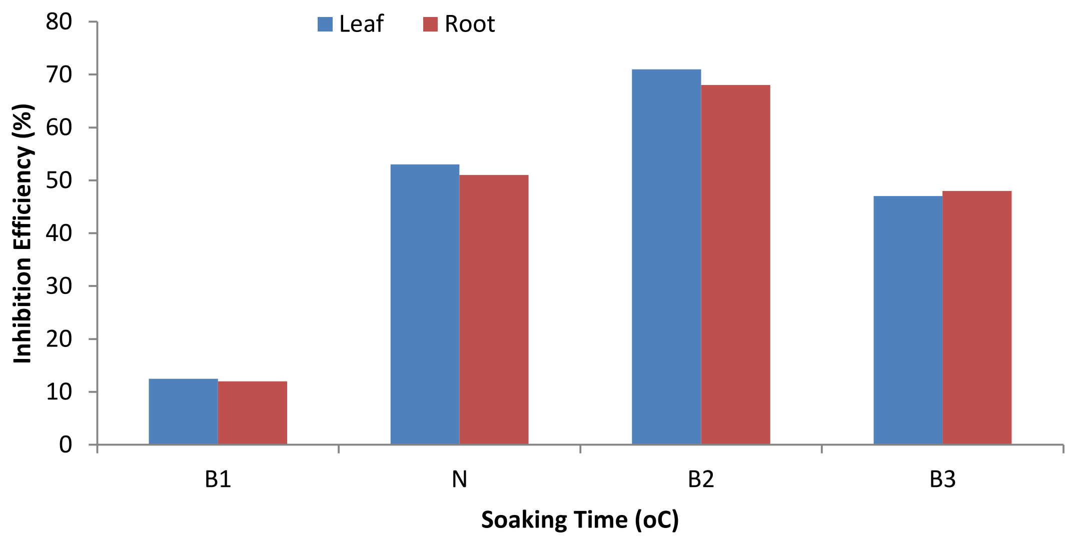


Figure 3: Variation of inhibition efficiency with respect to soaking temperature

CONCLUSION AND RECOMMENDATION

From the results of weight loss of corrosion rate of DPS using baobab leaf and root extract as corrosion inhibitor, the following conclusions were drawn:

- The extract baobab leaf and root extracts can be used as inhibitor on dual phase steel substrate.
- The corrosion rate in the presence of baobab leaf and root (inhibitor) decreases with increase in the concentration of the inhibitor
- The percentage inhibition efficiency (% IE) increased with increase in the soaking temperature of the developed DPS

Based on the above, it is recommended that baobab leaf and root extracts can competitively serve organic inhibitor to improve the corrosion resistance of DPS.

Acknowledgement

The authors of this article heartily appreciate the management of Tertiary Education Trust Fund (TETFund) for sponsoring this research and to the management of Kogi State Polytechnic, Nigeria for their support.

REFERENCE

Sachin. H.P, Moinuddin Khan M.H, Raghavendra S, and Bhujangaiah N.S.(2009): L-Dopa as Corrosion Inhibitor for Mild Steel in Mineral Acid Medium. The Open Electrochemistry Journal, 1, 15-18

YuliYetri, Emriadi, Novesar Jamarun, and Gunawarman,(2014): Corrosion Inhibition Efficiency of Mild Steel in Hydrochloric Acid by Adding Theobroma Cacao Peel Extract. *International Conference on Biological, Chemical and Environmental Sciences* (BCES-2014), June 14-15, Penang, (Malaysia)

HelenL. Y. S, Rahim A. A, Saad B, Saleh M. I, Bothi Raja P, (2013): AquilariaCrassna Leaves Extracts – a Green Corrosion Inhibitor for Mild Steel in 1 M HCl Medium. *International Journal of Electrochemical Science*, 9, 830 – 846

Lakshman, R.B. (2012): Phytochemical Screening Quantitative Estimation Total Phenolic and Total Flavonoids, Anti-Microbial Evaluation of CyamopsisTetragonoloba Int. J. of Research inPharmaceutical and Biomedical Sciences, Vol.3, pp 3, ISSN: 2229-3701

Buchweishaija J. (2009). Phytochemicals as green corrosion inhibitors in various corrosivemedia: a review. *Journal of Sciences*, 35:77–92.

Thompson N. G., Yunovich M., Dunmire D. (2007) Cost of corrosion and corrosion maintenance strategies. *Corrosion Reviews* 25(3–4):247–262.

Quraishi M. A., Obot I. B., Eddy N. O., Kabanda M. M., Shukla S. K., Singh A. K., Murulana L. C., Ebenso E. E., (2012). Electrochemical and quantum chemical studies on calmagite and fast sulphone black F dyes as corrosion inhibitors for mild steel in hydrochloric medium. *International Journal of Electrochemical Sciences* 7:8813–8831.

Ebenso E. E., Kabanda M. M., Arslan T, Saracoglu M, Kandemirli F, Murulana L. C.,Singh A. K., Shukla S. K., Hammouti B, Khaled K. F., (2012). Quantum chemical investigations onquinoline derivatives as effective corrosion inhibitors for mild steel in acidic medium.*International Journal of Electrochemical Science* 7:5643–5676

Abdulrahman, A.S. and Mohammad Ismail, (2011): Eco-friendly green inhibitor to improve the strength of concrete contaminated by chloride and sulphate. *International Journal of Research and Reviews in Applied Sciences*, 9(3): 355-360

Abdulrahman, A.S., M. Ismail., M.S. Hussain, (2011): Inhibition of Corrosion of Mild Steel inHydrochloric Acid by BambusaArundinacea. *International Review of Mechanical Engineering*, 5(1): 59-63.

Asipita,S.A., Mohammad Ismail., MuhdZaimiAbd Majid., Zaiton Abdul Majid. CheSobryAbdullah, Jahangir Mirza, (2014): Green BambusaArundinacea leaves extract as asustainable corrosion inhibitor in steel reinforced concrete. *Journal of Cleaner Production*, 67: 139-146.

Abd-El-Nabey B. A., Abdel-Gaber A. M., Elawady G. Y., El-Houssein S,(2012):Inhibitive action of some plant extracts on the alkaline corrosion of aluminum.*International Journal of Electrochemical Science* 7:7823–7839.

Loto T.R., Loto,C.A., and Popoola I.P.A.,(2012): Effect of Amino-benzeneConcentration onthe Corrosion inhibition of Mild Steel in Sulphuric acid. *International Journal of Electrochemical Science*, 7, 7016 – 7032.

Sachin. H.P, MoinuddinKhanM.H, Raghavendra S, and Bhujangaiah N.S.(2009):L-Dopa as Corrosion Inhibitor for Mild Steel in Mineral Acid Medium. The Open Electrochemistry Journal, 1, 15-18

Quraishi A. M., Ansari A. F., Jamal D., (2004): Corrosion inhibition of tin by some amino-acids incitric acid. *Indian Journal of Chemical Technology* 11:271–274.

Ebenso E. E., Kabanda M. M., Murulana L. C., Singh A. K., Shukla S. K., (2003):Electrochemical andquantum chemical investigation of some azine and thiazine dyes as potential corrosion inhibitors for mild steel in hydrochloric acid solution. IndEngChem Res 51:12940–12958.

Alaneme K.K., Daramola Y.S., Olusegun S.J. and Afolabi A.S. (2015): “Corrosion Inhibition and Adsorption Characteristics of Rice Husk Extracts on Mild Steel Immersed in 1M H_2SO_4 and HCl Solutions”. *International Journal of Electrochemical Science 10:3553 – 3567*

Alaneme K.K., Fajemisin A.J., OlusegunS.J andBorode, J.O. (2016):“Corrosion Inhibition and Adsorption Characteristics of TridaxProcumbens L Leaves Extract On Mild Steel Immersed In 1M Hcl Solution”. *Leonardo Electronic Journal of Practices and Technologies 29: 43-60. ISSN 1583- 1078*

Arockia S, Kamaraj, Arthanareeswari and Aminu D (2016): Corrosion Inhibition of Mild Steel in Acid Medium by MoringaOleifera and LettuciaEdibelia Extracts. *3 ISSN; 2347-7601*

Petro N. K. and Murthy H. C. A. (2017): "Methanolic Extracts of Adansonia-digitata (Baobab) Fruit Pulp and Seeds as Potential Green Inhibitors for Mild Steel Corrosion in 1.0 M H2SO4 solution." IOSR Journal of Applied Chemistry (IOSR-JAC) 10.7: 64-74.

Buchweishaija J. (2009). Phytochemicals as green corrosion inhibitors in various corrosivemedia: a review. *Journal of Sciences*, 35:77–92.