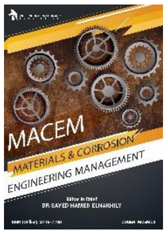
ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN: 2716-7100 (Online)
CODEN: MCEMC2

Materials & Corrosion Engineering Management (MACEM)

DOI: http://doi.org/10.26480/macem.01.2022.01.04



CrossMark

RESEARCH ARTICLE

SYNERGISTIC GREEN CORROSION INHIBITOR ON MILD STEEL IN 1M H_2SO_4 BY EXTRACT OF WILD YAM (*DIOSCOREA VILLOSA*)

Kaywood Elijah Leizou[a], Muhammad Aqeel Ashraf[b]

[a] Department of Chemical Sciences, Niger Delta University, Wilberforce Island, P.M.B 071, Yenagoa, Nigeria.
[b] International Water, Air & Soil Conservation Society INWASCON 59200 Kuala Lumpur, Malaysia.
**Corresponding Author Email: pastorkayeleizou@yahoo.com*

ARTICLE DETAILS

Article History:

Received 21 January 2022
Accepted 01 March 2022
Available online 07 March 2022

ABSTRACT

Corrosion is a serious threat to the long-term function and integrity of steel. Structural steel will corrode if left exposed or incorrectly shielded from the natural environment. Corrosion might take the form of general uniform thickness loss or localized pitting, depending on the climate. The goal of this study is to use the weight loss method to determine the mode of action of wild yam (dioscorea villosa) extract on mild steel in a 1 M H2SO4 solution. The synergistic corrosion inhibition of mild steel in 1M H2SO4 media utilizing extract of wild yam (dioscorea villosa) was examined using the weight loss method. The inhibitory efficacy of the extracts improved as the concentration of the extract increased but reduced as the temperature increased. Inhibition was found to be beneficial in a range of situations: *16.67-33.33% at 30°C, 28.50-57.14% at 40°C, 11.11-44.44% at 50°C, 7.41-18.52% at 60°C and 7.69-15.31% at 70°C.* A wild yam (dioscorea villosa) extract reduced mild steel corrosion, according to the findings. The extract of wild yam (dioscorea villosa) is a good synergistic green corrosion inhibitor since it reduces the rate of corrosion significantly.

KEYWORDS

Synergistic, green *corrosion inhibitor, weight loss, wild yam (dioscorea villosa)*

1. INTRODUCTION

Corrosion inhibition is the process of employing synthetic, natural compounds, or extracts of natural plants to prevent or manage environmental attack, corrosion, or corrosive attack on steel and alloys that could cause harm. Eco-friendly, biodegradable, non-toxic, cost-effective, naturally abundant, and easily available bio-corrosion inhibitors are the way ahead in an era of constant and ongoing quest for solutions to environmental degradation and corrosion prevention. As a result, plant-derived compounds make good inhibitors (Manickam et al., 2016). The importance of inhibitors in preventing aggressive anions from adsorbing and lowering the passivating oxide dissolution rate cannot be overstated (Gupta et al., 2013). Metal corrosion continues to be a global scientific issue, affecting the metallurgical, chemical, construction, and oil industries. The growing interest in the manufacture and use of sulphuric acid in applications that use a lot of mild steel has necessitated the gathering of data on mild steel's corrosion resistance to sulphuric acid attack (Durowaye et al., 2014).

When complex microbial consortia interact with metallic surfaces by forming multi-species biofilms, biocorrosion develops (Costerton et al., 1995; Solomon et al., 2019). Corrosion inhibitors are one of the most practical and cost-effective ways to keep metals from corroding. They could be inorganic or organic materials. Metal corrosion inhibitors must be able to quickly oxidize the metal in order to generate an impermeable layer that prevents direct ions-metal interaction and so slows the rate of metal dissolution in the medium (Nnanna et al., 2014). The sorts of functional groups, the quantity and type of adsorption sites, the charge distribution in the molecules, and the type of interaction between the inhibitors and the metal surface are all important aspects in the inhibitors' action (Ebadi et al., 2012; El-Dahan et al., 2005). More study is needed, however, given the vast amount of plant resources and the potential demand for effective green corrosion inhibitors. Furthermore, the phytochemical cations are still scarcely invested in the efficient inhibitive composition of plant extracts, which is vital for understanding the inhibition mechanism of plant extracts and the creation of novel inhibitors.

Plant extracts are being studied extensively as corrosion inhibitors since they are highly eco-friendly and pose little risk to the environment (Okafur et al., 2005). The corrosion inhibition of mild steel in 0.5M H_2SO_4 using loquat (eriobotrya japonica Lindl.) leaves extract was investigated, and it was discovered that it acted as a modest cathodic inhibitor, with inhibition efficiency increasing with LLE concentration and reaching a maximum of 96 percent at 100 percent V/V concentration, but decreasing with incremental temperature (Zheng et al., 2018). Pentaclethramacrophylla bentham extract inhibited mild steel corrosion in HCl solution, and it was discovered that pentaclethramacrophylla bentham extracts slowed the dissolving of mild steel in 1.0 M HCl solution (Nnanna et al., 2014). The efficiency of inhibition rose as the extract concentration was increased, and it improved dramatically as the temperature was raised. A group researchers investigated mild steel corrosion inhibition in 1M HCl (Manickam et al., 2016). Gum exudates from Azadirachtaindica were reported to reduce corrosion rate up to a concentration of 80 ppm and at a temperature of 323 K.

Dioscorea villosa, also known as wild yam, colic root, rheumatic root, devil's bones, and four-leaf yam, is a twining tuberous vine endemic to eastern North America. Previous researchers had not attempted to employ

Quick Response Code	Access this article online	
	Website: www.macej.com.my	**DOI:** 10.26480/macem.01.2022.01.04

Cite the Article: Kaywood Elijah Leizou, Muhammad Aqeel Ashraf (2022). Synergistic Green Corrosion Inhibitor on Mild Steel in 1M H_2SO_4 by Extract of Wild Yam *(Dioscorea Villosa). Materials & Corrosion Engineering Management, 3(1): 01-04.*

wild yam (dioscorea villosa) for corrosion inhibition. Because wild yam is abundant and corrosion prevention has become a difficult issue for companies large and small in industrialized and emerging countries, this study is of interest. The major goal of this study was to see how well wild yam (dioscorea villosa) extract inhibited corrosion on mild steel in 1M sulphuric acid solutions, in order to determine its efficacy in corrosion prevention.

2. Materials and Methods

Figure 1: Images of wild yam *(dioscorea villosa*)

2.1 Preparation of the Sample and Reagents

Wild yam samples were collected in abundance from local farmers in Amassoma Town, Bayelsa State's Southern Ijaw Local Government Area. The samples were rinsed with distilled water and air dried for 72 hours after being washed with running tap water. The samples were then oven dried for 48 hours at 105°C before being trimmed to powdered form. 100 g of powder was placed in a flask with a flat bottom and 1000 liters of ethanol. The final solution was allowed to sit for 72 hours before being filtered. The stocks solution was made from the filtrate, which was evaporated and then used to generate green inhibitor solutions with concentrations of (0.2, 0.4, and 0.6) g/L. Then, to make a 1M solution of H_2SO_4, 54.35mL of concentrated H_2SO_4 was diluted with 1000mL of distilled water. Analytical grade reagents were employed. All glassware was cleansed with liquid detergent and rinsed three times before being dried in the oven.

2.2 Weight Loss Measurements

For the weight loss measurement, standard G-31 method given was used (ASTM, 2004; Manickam et al., 2016; Royani et al., 2019). For weight loss measurements, the mild steel was mechanically press-cut into coupons with dimensions of 5cm 4cm. Prior to use, the coupons were ground using various grades of silicon carbide paper, degreased in 100% ethanol, air dried, and kept in moisture-free desiccators. In a controlled setting, the weighed specimens were immersed in the corrosive medium with and without inhibitors for a specified immersion period (2, 4, 6, 8, and 10 hours) and at five different temperatures (30°C, 40°C, 50°C, 60°C, and 70°C). The specimens were withdrawn from the acid solution after the experiment and rinsed with water, cleaned with acetone, air dried, and weighed. Equation one was used to compute the corrosion rate and inhibition efficiency using the mean weight loss values.

$$CR\ (mmpy) = \frac{87.6\ X\ W}{DAT} \quad (1)$$

Where:

W = weight loss in milligrams

D = metal density in g/cm3

A = area of the sample in cm^2

T = time of exposure of the metal sample in hours.

3. Results and Discussion

The behavior and efficacy of wild yam (dioscorea villosa) extract as a synergistic green corrosion inhibitor in various concentrations (0.2, 0.4, and 0.6) g/L on mild steel with the following composition: C(0.16 %), Si(0.20 %), F(0.04 %), Mn(0.85 %), Ni(0.10 %), Cr(0.20 %), Mo(0.02 %), V(0.001 %), and for various immersion periods (0.35 (2, 4, 6, 8 and 10 hours) was investigated for the temperature ranges of 30–70°C. The corrosion rate and inhibition efficiency were computed, and the results are shown in Table 1, as well as a graphic representation of the weight loss fluctuation in Figures 2-6. The wet-dry cycle accelerates rusting processes, particularly precipitation and transformation with deprotonation and dehydration, according to (Royani et al., 2019). Described the rust product's mechanism in the wet-dry cycle in three stages as follows (Liu et al., 2014; Royani et al., 2019):

Stage 1: After wetting the dry surface, a corrosion cell forms, in which anodic iron dissolution is balanced by cathodic Fe (III) reduction in the rust layer:

$$Fe \rightarrow Fe^{2+} + 2e^- \quad (2)$$

$$2FeOOH + 2H^+ + 2e^- \rightarrow 2FeO.H_2O \quad (3)$$

In comparison to anodic iron dissolution, the cathodic O2 reduction reaction is quite sluggish at this stage. Although the rate of metal dissolution is fast, the amount of dissolved iron is limited by the amount of reducible FeOOH in the rust layer (Royani et al., 2019).

Stage 2: a dripping wet surface

The O_2 reduction reaction becomes the cathodic reaction once the reducible FeOOH has been used up:

$$Fe \rightarrow Fe^{2+} + 2e^- \quad (4)$$

$$½O_2 + H_2O + 2e^- \rightarrow 2OH^- \quad (5)$$

Stage 3: drying-out of the surface

Due to the weakening of the electrolyte film on the inner surface of the rust layer after drying out, the diffusion limited O2 reduction reaction occurs at an incredibly fast pace. As a result, the corrosion rate is quite high, with O_2 reduction acting as the cathodic reaction once again.

$$Fe \rightarrow Fe^{2+} + 2e^- \quad (6)$$

$$½O_2 + H_2O + 2e^- \rightarrow 2OH^- \quad (7)$$

$$2FeO.H_2O + 2O_2 \rightarrow 2FeOOH + H_2O \quad (8)$$

Furthermore, O_2 has the ability to reoxidize the reduced Fe2+ generated in stage 1. Stage 3 appears to dominate metal loss during the whole wet-dry cycle as a result of the high corrosion rate. That is, the FeOOH (rust) level rises after each wet-dry cycle. The rust itself participated in the corrosion processes, increasing the wet-dry sample's corrosion rate (Liu et al., 2014).

After 2 hours of immersion at temperatures ranging from 30oC to 40oC, 50°C to 60 °C, and 70oC, the corrosion rate ranged from 0.00-0.0278, 0.0278-0.0278, 0.0278-0.5572, and 0.05572-0.1950, respectively. At 60 °C, the corrosion rate was highest, while at 30oC, it was lowest. The corrosion rate ranged from 0.0279-0.0479, 0.0139-0.0278, 0.0278-0.0557, 0.0557-0.0975 and 0.04197-0.1253 after 4 hours of immersion at temperatures of 30 °C, 40 °C, 50 °C, 60 °C, and 70 °C. Similarly, the highest corrosion rate was recorded at 70oC, while the lowest corrosion rate was recorded at 30 °C.

The corrosion rate ranged from 0.0185-0.0371, 0.0092-0.0278, 0.0371-0.0464, 0.0557-0.1021 and 0.0464-0.1253 at temperatures of 30 °C, 40 °C, 50 °C, 60 °C, and 70 °C and for 6 hours of immersion. For 8 hours immersion at 30 °C, 40 °C, 50oC, 60 °C, and 70 °C, the corrosion rate ranged from 0.0278-0.0417, 0.0139-0.0348, 0.0487-0.0487, 0.0997-0.1184, and 0.0557-0.0766. The corrosion rate was 0.0202-0.034, 0.0167-0.0390, 0.0390-0.0515, 0.1225-0.1504 and 0.05015-0.0724 after 10 hours of immersion at temperatures of 30 °C, 40 °C, 50 °C, 60 °C, and 70°C.

The results (Table 1) revealed that increasing the inhibitor concentration from 0.20g/L to 0.60g/L increased inhibition efficiency, with 0.60g/L achieving the highest inhibition efficiency for various immersion periods of the study temperature ranges (30–70) oC. According to corrosion rates decrease with exposure time (Liu et al., 2014). The thickening of the passive film on the alloy surface could explain the decrease in corrosion rate of carbon steel over time. Because of their availability and ease of use, organic corrosion inhibitors have been widely used to solve corrosion problems. In conjugate systems, organic corrosion inhibitors are typically composed of heteroatoms such as nitrogen, sulfur, and oxygen. The heteroatom is used for adsorption on the metal's surface (Obot et al., 2008; Oguzie, 2007). According to research, compounds containing the functional groups -NH2, -N=N, -C=N, -S-CH3, -C=S, -N-H, -CO, -CNS, -CHO inhibit metal corrosion (Rudesh and Mayanna, 1977; Xueyuang et al., 2001; Morad and El-Dean, 2006; Raymond et al., 2013; Ngobiri et al., 2015).

Table 1: Corrosion rate of wild yam on mild steel in 1M H_2SO_4 for various immersion periods and temperatures

Time (hours)	Concen. (g/L)	30°C	40°C	50°C	60°C	70°C	IE (%)
		CR mmpy	CR mmpy	CR mmpy	CR mmpy	CR mmpy	
2	Blank	0.00	0.00	0.0278	0.5572	0.05572	-
	0.2	0.0279	0.00	0.0278	0.5572	0.05572	16.67%
	0.4	0.0279	0.00	0.0278	0.0278	0.05572	33.33%
	0.6	0.0279	0.0278	0.0278	0.0278	0.1950	-
4	Blank	0.0139	0.0139	0.0557	0.0835	0.04179	-
	0.2	0.0279	0.0139	0.0417	0.0975	0.05572	57.14%
	0.4	0.0279	0.0139	0.0278	0.0557	0.04179	42.86%
	0.6	0.0479	0.0278	0.0557	0.0557	0.1253	28.57%
6	Blank	0.0371	0.0278	0.0464	0.1021	0.0464	-
	0.2	0.0371	0.0092	0.0371	0.1021	0.0650	11.11
	0.4	0.0185	0.0185	0.0464	0.8358	0.05572	22.22
	0.6	0.0371	0.0278	0.0464	0.0743	0.07430	44.44
8	Blank	0.0348	0.0348	0.0487	0.1114	0.06269	-
	0.2	0.0348	0.0139	0.0487	0.1044	0.06765	7.41
	0.4	0.0278	0.0139	0.0487	0.1184	0.05572	11.11
	0.6	0.0417	0.0208	0.0487	0.0975	0.07662	18.52
10	Blank	0.0334	0.0390	0.0515	0.1504	0.07244	-
	0.2	0.0278	0.0167	0.0445	0.1393	0.06129	15.31%
	0.4	0.0222	0.0222	0.0390	0.1337	0.05015	30.77%
	0.6	0.0334	0.0278	0.0501	0.1225	0.06687	7.69

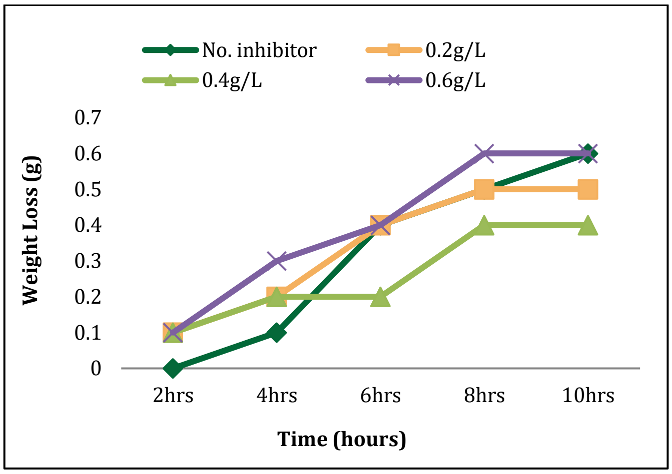


Figure 2: variation of weight loss (g) of mild steel at 30°C of

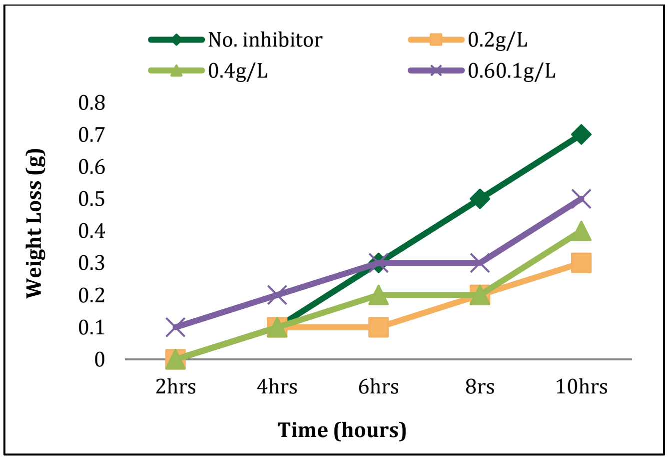


Figure 3: variation of weight loss (g) of mild steel at 40°C

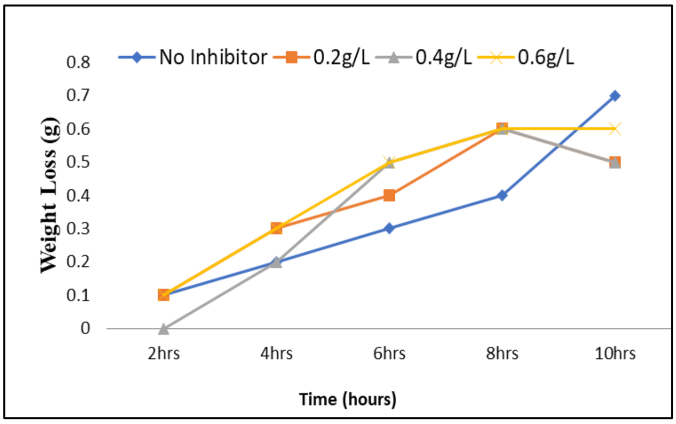


Figure 4: variation of weight loss (g) of mild steel at 50°C

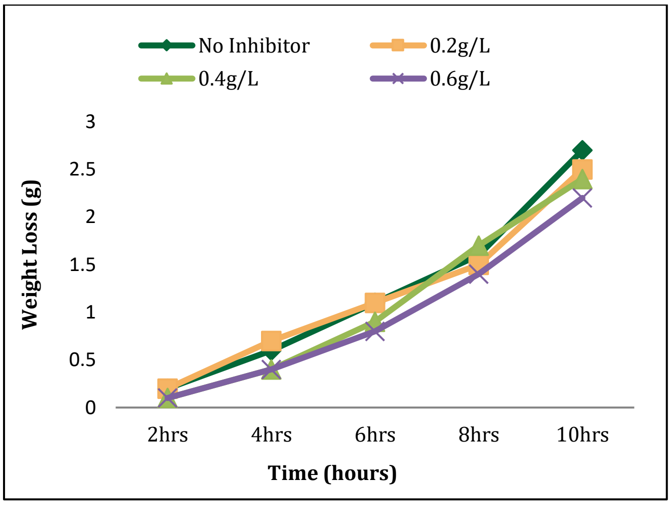


Figure 5: variation of weight loss (g) of mild steel at 60°C

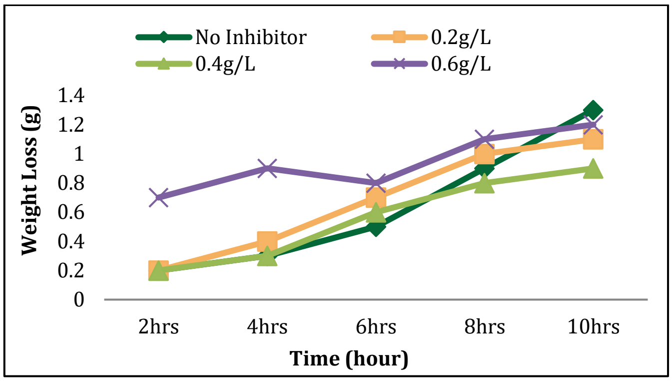


Figure 6: Variation of weight loss (g) of mild steel at 70°C

As the temperature rises, so does the rate of weight loss. This means that when the temperature rose, the solubility of the metals increased. This finding is explained by the basic rule governing the rate of chemical reaction, which states that the rate of chemical reaction increases as the temperature rises. An increase in temperature also stimulates the creation of activated molecules, which can double in number with a 10°C increase in temperature, resulting in a faster response rate. This is due to the reactant molecules gaining more energy and being able to break through the energy barrier faster (James et al., 2007; Ita and Offiong, 1997). Temperature increases the solubility of protective coatings on metals, increasing the metal's vulnerability to corrosion (Okafor et al., 2004). As the temperature rises, the solubility of oxygen gas drops. As a result, at greater temperatures, oxygen concentration is projected to be higher. As a result of the high oxygen concentration, the metal corrodes more quickly. This explains why, as the temperature rises, the solid protective coating becomes increasingly dissolving. Furthermore, when the concentration of the plant extract increased, the inhibitor's (wild yam) inhibitory efficacy increased, but as the temperature climbed, it reduced. Finally, it's vital to note that explaining the adsorption mechanism of natural product extracts is difficult (Bouhlal et al., 2020). This is due to a lack of understanding of the extract's molecular structure and number of chemical components.

4. Conclusion

In this work, wild yam extract inhibited corrosion in a 1M H2SO4 acid solution. When employed at the proper concentration, the plant extract functions as a good green inhibitor on mild steel in acidic medium and can be used to slow down the corrosion rate on mild steel. There was a steady rise in weight loss when the temperature was raised, indicating that the metal was dissolving faster at higher temperatures. As a result, wild yam extract is regarded as a good corrosion inhibitor, as the rate of corrosion is significantly reduced in the presence of the inhibitor.

References

ASTM. 2004. Practice Standard G-31, Standard Practice for Laboratory Immersion Corrosion Testing of Metals, ASTM International, West Conshohocken, Pa, USA.

Bouhlal, F., Labjar, N., Abdoun, F., Mazkour, A., Serghini-Idrissi, M., El Mahi, M., El Mostapha, L., and El Hajjaji, S., 2020. Electrochemical and thermodynamic investigation on corrosion inhibition of C38 Steel in 1M hydrochloric Acid using the hydro-alcoholic extract of used Coffee grounds. International Journal of Corrosion, Pp. 1-14.

Costerton, J.W., Lewandowski, Z., Coldwell, D.E., Korber, D.R., Lappin Scott, H.M., 1995. Microbial biofilms. Annual Rev Microbiol, 49, Pp. 711-745.

Durowaye, S.I., Durowaye, V.O., Begusa, B.M., 2014. Corrosion Inhibition of Mild Steel in Acidic Medium by Methyl Red (2, 4-Dimethylamino-2'-carboxylazobenzene). International Journal of Engineering and Technology, 4 (8), Pp. 469-475.

Ebadi, M., Basirun, W.J., Khaledi, H., Ali, H.M., 2012. Corrosion inhibition properties ofpyrazolylindolenine compounds on copper surface in acidic media. Chemistry Central Journal, 6, Pp. 163. doi:10.1186/1752-153X-6-163.

E1-Dahan, H.A., Soror, T.Y., El-Sherif, R.M., 2005. Studies on the inhibition of aluminum dissolution by hexamine–halide blends. Mater ChemPhys., 89, Pp. 260–267.

Gupta, M., Mishra, J., Pitre, K.S., 2013. Corrosion and Inhibition Effects of Mild Steel in HydrochloricAcid Solutions Containing Organophosphonic Acid. Hindawi Publishing Corporation, International Journal of Corrosion, Pp. 1-5.

Ita, B.I., and Offiong, O.E., 1997. Inhibition of steel corrosion in hydrochloric acid by pyridoxal, 4 –methyl thiosemicarbazide, pyrdoxal – (4 – methylthiosemicarbazone) and its Zn(11) complex, Mater. Chem. Phys., 48, Pp. 164 –169.

James, A.O., Oforka, N.C., Abiola, A.K., and Ita, B.I., 2007. A study on the inhibition of mild steel corrosion in hydrochloric acid by pyridoxol hydrochloride. Eclética Química, 32 (3), Pp. 31-37.

Liu, J.G., Li, Z.L., Li, Y.T., and Hou, B.R., 2014. Corrosion Behavior of D32 Rust Steel in Seawater. Int J Electrochem Sci., 9, Pp. 6699 – 6706.

Manickam, M., Sivakumar, D., Thirumalairaj, B., and Jaganathan, M., 2016. Corrosion inhibition of mild steel in 1Mol L^{-1}HCl using gum exudates of azadirachtaindica. Advances in Physical Chemistry, Pp. 1-12.

Morad, M.S., El-Dean, A.M.K., 2006. 2,20-dithiobis(3-cyno-4,6-dimethylpyridine): a new class of acid corrosion inhibitors for mildsteel. Corros. Sci., 48, Pp. 3398–3412.

Ngobiri, N.C., Oguzie, E.E., Oforka, N.C., and Akaranta, O., 2015. Comparative study on the inhibitive effect of Sulfadoxine–Pyrimethamine and an industrial inhibitor on the corrosion of pipeline steel in petroleum pipeline water. Arabian Journal of Chemistry, Pp. 1-11. http://dx.doi.org/10.1016/j.arabjc.2015.04.004.

Nnanna, L.A., Owate, I.O., and Oguzie, E.E., 2014. Inhibition of Mild Steel Corrosion in HCl Solution by Pentaclethramacrophylla Bentham Extract. International Journal of Materials Engineering, 4 (5), Pp. 171-179. DOI: 10.5923/j.ijme.20140405.02.

Obot, I.B., Ebenso, E.E., Gasem, Z.M., 2008. Eco-friendly corrosion inhibitor: adsorption and inhibitive action of ethanol extract of Chlomolaena Odorata L. for the corrosion of mild steel in H_2SO_4 solution. Int. J. Electrochem., 7.

Oguzie, E.E., 2007. Corrosion inhibition of aluminium in acidic and alkaline media by Sansevieria trifasciata extract. Corros. Sci., 49, 1527–1539.

Okafor, P.C., Ekpe, U.J., Ebenso, E.E., Umoren, E.M., Leizou, K.E., 2005. Inhibition of mild steel corrosion in acidic medium by allium sativum extracts Bulletin Electrochemistry, 21 (8), Pp. 347-352.

Okafor, P.C., Ebenso, E.E., Ekpe, U.J., 2004. Inhibition of the acid corrosion of aluminum bysome derivatives of thiosemicarbazone. Bull. Chem. Soc. Ethiopia, 18, (12), Pp. 181 – 192.

Raymond, P.P., Regis, P.P.A., Rajendram, S., and Manivannan, M., 2013. Investigation of corrosion inhibition of stainless steel by sodium tungstate. Res. J. Chem. Sci., 3 (2), Pp. 54–58.

Royani, A., Prifiharni, S., Nuraini, L., Priyotomo, G., Purawiardi, S.I., and Gunawan, H., 2019. Corrosion of carbon steel after exposure in the river of Sukabumi, WestJava. IOP Conf. Series: Materials Science and Engineering, 541, Pp. 012031. IOP Publishing doi:10.1088/1757-899X/541/1/012031, 2019.

Rudesh, H.B., and Mayanna, S.M., 1977. Adsorption of n-Decyllamine on zinc from acidic chloride solution. J. Electrochem. Soc., 124 (3), Pp. 340–342.

Solomon, L., Daminabo, V., and George, O., 2019. West: Biocorrosion inhibition efficiency of locally sourced plant extracts obtained from aloe vera (barbadensis miller) and scent leaf (ocimumgratissimum). J. Biotechnol. Biomater., 8, Pp. 289. doi: 10.4172/2155-952X.1000289.

Xueyuang, Z., Fengping, W., Yufang, H., and Yuanlong, D., 2001. Study of the inhibition mechanism of imidazoline amide on CO_2 corrosion of Armco iron. Corros. Sci., 43, Pp. 1417–1431.

Zheng, X., Gong, M., Li, Q., and Guo, L., 2018. Corrosion inhibition of mild steelin sulfuric acid solution by loquat (Eriobotrya japonica Lindl.) leaves extract. Scientific Reports, 8, 9140, 2018. 1-15.| DOI:10.1038/s41598-018-27257-9

Cite the Article: Kaywood Elijah Leizou, Muhammad Aqeel Ashraf (2022). Synergistic Green Corrosion Inhibitor on Mild Steel in 1M H_2SO_4 by Extract of Wild Yam *(Dioscorea Villosa). Materials & Corrosion Engineering Management, 3(1): 01-04.*