OPEN ACCESS

Saudi Journal of Engineering and Technology
Abbreviated Key Title: Saudi J Eng Technol
ISSN 2415-6272 (Print) |ISSN 2415-6264 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Corrosion Behavior of Extracts of Yam, Maize and Cassava Leaves on Mild Steel in a Selected Media

Blessing J. Ifeanyichukwu[1*], Ndubuisi E. Idenyi[2], Ozoekwem Raphael Obinna[3]

[1]Physics Advanced Research Centre, Sheda Science and Technology Complex, Abuja, Nigeria
[2]Department of Mechanical/Bioresources Engineering, Ebonyi State University, Abakaliki, Nigeria
[3]Department of Mechanical Engineering, Alex Ekwueme Federal University, Ndufu-Alike, Ikwo, Nigeria

DOI: https://doi.org/10.36348/sjet.2025.v10i03.004 | **Received:** 07.02.2025 | **Accepted:** 15.03.2025 | **Published:** 20.03.2025

***Corresponding author:** Blessing J. Ifeanyichukwu
Physics Advanced Research Centre, Sheda Science and Technology Complex, Abuja, Nigeria

Abstract

Investigation of the inhibiting effects of *Dioscorea rotundata*, *Zea mays* and *Manihot exculenta* leaves extracts on the corrosion of mild steel in ~~a~~ selected media using weight loss method was carried out. The mild steel samples were pre-weighed, immersed in mixture of NaOH, NaCl and H_2SO_4 solutions with the extracts from the leaves and the control samples immersed in solution of the media with no extracts. The samples were allowed to stand for 672 hours and a set of samples from each environment withdrawn at intervals of 168 hours for corrosion characterization. The research findings indicate that the corrosion rate decreased as a result of the leaves extracts introduced into the media thereby confirming that the extracts functioned as effective and excellent inhibitors in the alkaline, salt and acidic media. Among the three plants extracts used, it was observed that *Dioscorea rotundata* (Yam) has the best inhibition efficiency in both alkaline, salt and acidic media, followed by *Manihot exculenta* (Cassava) and *Zea mays* (Maize) which also showed good inhibition efficiency. The results show the very good potentialities of the leaves extracts for application in the mitigation of corrosion in our various manufacturing industries.

Keywords: Corrosion, Inhibiting effects, Leaves extracts, Mild steel.

INTRODUTION

Applications of new green inhibitors have continued to gain interest in the technological world. In the field of material science and corrosion control, scientists are persistent in seeking better and more efficient ways of combating the corrosion of metals (Ifeanyichukwu and Nwifior, 2024; Idenyi, Nwofe~~,~~ and Idu, 2015).

The consequences of the corrosive effects are remarkable in food processing industry as leaves contain corrosion aggressive substances, such as tannins, saponins and flavonoids etc. (Ifeanyichukwu and Idenyi, 2023; Ifeanyichukwu and Nwifior, 2024; Jamiu and Olorunfemi, 2013), thereby causing significant impact on the degradation of constructional materials and the maintenance or replacement of products lost or contaminated as a result of corrosion reactions. Corrosion has posed to be more of a nuisance than good (Ifeanyichukwu and Nwifior, 2024; JL Shadma, Shanthi and Rajiv, 2015).

Acid solutions are used in the most important industrial applications in etching and acidic cleaning. Hydrogen tetraoxosulphate (vi) acid is widely used for the removal of rust and industrial acid cleaning, acid descaling and oil well acidizing, because of the general aggressiveness of acid solutions. The practice of inhibition is commonly used to reduce the corrosive attack on metallic materials. Inhibitors are generally used for this purpose to control the metal dissolution. A number of studies have recently appeared in the literature on the corrosion of mild steel in acidic solutions. The important materials used in the manufacturing sector are mild steel. Mild Steel is widely used in the construction of machine parts that are employed in manufacturing, processing and production industries. The best approach to mitigate corrosion of these structures is to study the corrosive behaviour of this metallic material in an environment concerned in order to proffer appropriate method of protection (Helen, Rahim, Ibrahim and Brosse, 2016; Mourya, Banerjee and Singh, 2014). Mild steel corrodes when exposed to air and the oxide formed on it is readily broken down, in the presence of moisture, especially if it is not repaired (Mohsin, Husam and Rasha, 2014).

Yam is the common name for some plant species in the genus *Dioscorea* (family Dioscoreaceae) that form edible tubers (some other species in the genus being toxic). Yams are perennial herbaceous vines native to Africa, Asia, and the Americas and cultivated for the consumption of their starchy tubers in many temperate and tropical regions. The tubers themselves, also called "yams", come in a variety of forms owing to numerous cultivars and related species.

A monocot related to lilies and grasses, yams are vigorous herbaceous, perennially growing vines from a tuber. Some 870 species of yams are known, a few of which are widely grown for their edible tuber but others of which are toxic (such as *Dioscorea communis*).

Yam plants can grow up to 15 metres (49 feet) in length and 7.6 to 15.2 centimetres (3 to 6 inches) high. The tuber may grow into the soil up to 1.5 m (5 ft) deep. The plant disperses by seed. The edible tuber has a rough skin that is difficult to peel but readily softened by cooking. The skins vary in color from dark brown to light pink. The majority, or meat, of the vegetable is composed of a much softer substance ranging in color from white or yellow to purple or pink in mature yams.

The name "yam" appears to derive from Portuguese *inhame* or Canarian Spanish *ñame*, which derived from Fula, one of the West African languages during trade. However, in Portuguese, this name commonly refers to the tado plant (*Colocasia esculenta*) from the genus Colocasia, as opposed to *Dioscorea*. The main derivations borrow from verbs meaning "to eat". True yams have various common names across multiple world regions. Yams are native to Africa, Asia, and the Americas. (Wikipedia; The free Encyclopedia). Three species were independently domesticated on those continents *Dioscorea rotundata*: (Africa), *Dioscorea alata* (Asia), and *Dioscorea trifida* (South America), (Nora Scarcelli, *et al*., 2017).

Yams are cultivated for the consumption of their starchy tubers in many temperate and tropical regions, especially in West Africa, South America and the Caribean Asia, and Oceania. About 95% of yam crops are grown in Africa (Library of Congress, USA. 2011).

A yam crop begins when whole seed tubers or tuber portions are planted into mounds or ridges, at the beginning of the rainy season. The crop yield depends on how and where the sets are planted, sizes of mounds, interplant spacing, provision of stakes for the resultant plants, yam species, and tuber sizes desired at harvest. Small-scale farmers in West and Central Africa often intercrop yams with cereals and vegetables. The seed yams are perishable and bulky to transport. Farmers who do not buy new seed yams usually set aside up to 30% of their harvest for planting the next year. Yam crops face pressure from a range of ins.ect pests and fungal and viral diseases, as well as nematode. Their growth and dormant phases correspond respectively to the wet season and the dry season. For maximum yield, the yams require a humid tropical environment, with an annual rainfall over 1,500 millimetres (59 in) distributed uniformly throughout the growing season. White, yellow, and water yams typically produce a single large tuber per year, generally weighing 5 to 10 kilograms (11 to 22 pounds), (Calvery, 1998).

Yams suffer from relatively few pests and diseases (Winch *et al*., 1984). There is an anthrtacnose caused by Colletotrichum gloeosporioides which is widely distributed around the world's growing regions. Winch *et al.*, 1984 finds *C. gloeosporioides* afflicts a large number of *Dioscorea* spp. *Dioscorea rotundata* the white yam, and *Dioscorea cavenensis* the yellow yam, are native to Africa. They are the most important cultivated yams. In the past, they were considered as two separate species, but most taxonomists now regard them as the same species. Over 200 varieties between them are cultivated (Wikipedia; The free Encyclopedia). White yam tuber is roughly cylindrical in shape, the skin is smooth and brown, and the flesh is usually white and firm. Yellow yam has yellow flesh, caused by the presence of carotenoids. It looks similar to the white yam in outer appearance; its tuber skin is usually a bit firmer and less extensively grooved. The yellow yam has a longer period of vegetation and a shorter dormancy than white yam. The kokoro variety is important in making dried yam chips (Dumont and Vernier, 2000).

They are large plants and the vines can be as long as 10 to 12 m (33 to 39 ft). The tubers most often weigh about 2.5 to 5 kg (6 to 11 lb) each, but can weigh as much as 25 kg (55 lb). After 7 to 12 months' growth, the tubers are harvested. In Africa, most are pounded into a paste to make the traditional dish of "pounded yam", known as Iyan (Kay, 1987). Despite the high labor requirements and production costs, consumer demand for yam is high in certain subregions of Africa, making yam cultivation quite profitable to certain farmers.

Some research has shown that yam leaves are more nutritious than spinach, celery, carrots and cucumbers when it comes to vitamin B, iron, zinc, protein, antioxidants, and calcium. They supposedly enhance immune function, boost metabolism, lower blood sugar, improve eyesight, and act as an anti-inflammatory.

I several formulations however, tubers of different Dioscorea species are used as a cure for different diseases and ailments such as cold, cough, stomach ache, dysentery, leprosy, burns, fungal infections, skin diseases, rheumatism, arthritis, and even for birth control.

Some Dioscorea species produce edible leaves which are localized to specific regions of the world, mainly in India, Africa, and some parts of Asia. Many Dioscorea species can also be toxic, so care and research should be taken before foraging leaves from wild plants.

Cassava **(***Manihot esculenta),* commonly called cassava manioc, yuca, or tapioca (among numerous regional names) is a woody shrub of the spurge family, Euphorbiaceae. It is a food plant that is also used medicinally to treat headache, irritable bowel syndrome, hypertension, pains and fever. The bitter variety leaves of Manihot esculenta are also used to treat hypertension, headache, and pain.

People use this root vegetable as a food and to make medicine.

Cassava root and leaves are eaten as food.

Cassava is a calorie-rich vegetable that contains plenty of carbohydrates and key vitamins and minerals. Cassava is a good source of vitamin C, thiamine, riboflavin and niacin. The leaves, which are also edible if a person cooks them or dries them in the sun, can contain up to 25% protein.

Cassava is a versatile crop and can be processed into a wide range of products such as starch, flour, tapioca, beverages and cassava chips for animal feed. Cassava is also gaining prominence as an important crop for the emerging bio-fuel industry and, as corroborated by Ziska *et al.* (2009), is a potential carbohydrate source for ethanol production. A well planned strategy for the development and utilization of cassava and cassava products can provide incentives for farmers, crop vendors and food processors to increase their incomes. It can also provide food security for households producing and consuming cassava and cassava products (Plucknett *et al,* 1998).

Maize (*Zea mayz)* called corn in some countries, is a member of the grass family Poaceae. Maize is a cereal grain which was first grown by people in ancient Central America. Approximately 1 billion tonnes are harvested every year. However, little of this maize is eaten directly by humans. Most is used to make corn ethanol, animal feed and other maize products, such as corn starch and corn syrup (The American Heritage Dictionary of the English Language, Fifth Edition).

Maize is a leafy stalk whose kernels have seeds inside. It is an angiosperm, which means that its seeds are enclosed inside a fruit or shell. It has long been a staple food by many people in Mexico Central and South America and parts of Africa. In Europe and the rest of North America, maize is grown mostly for use as animal feed. In Canada and the United States, maize is commonly referred to as "corn" (Simple English Wikipedia, the free encyclopedia). Centuries of cross breeding have produced larger plants, and specialized varieties. Corn has become an important ingredient in American foods through the use of corn starch. People have long eaten sweet corn and popcorn with little processing, and other kinds after processing into flour for making cornbread, tortillas, and other artificial foods.

Maize has been a fruitful model organism for research in genetics for many years: Research has shown that artificial selection developed maize from a Mexican plant called Teosinte (Doebley, 2004).

Africans consume maize as starch based in a wide variety of porridges, pastes, grits, and beer. Green maize (fresh on the cob) is eaten parched, baked, roasted or boiled and plays an important role in filling the hunger gap after the dry season. Maize grains have great nutritional value as they contain 72 % starch, 10 % protein, 4.8 % oil, 8.5 % fiber, 3.0 % sugar and 1.7 % ash (Chaudhary, 1983). Zea mays is the most important cereal fodder and grain crop under both irrigated and rain fed agricultural systems in the semi-arid and arid tropics (Ifeanyichukwu & Nwifior, 2024; Hussan *et al*, 2003).

METHODOLOGY

The mild steel rods were sourced from the metal stockiest. The composition of the mild steel rods was analyzed using Optical Emission Spectroscopy. The cylindrical mild steel samples 8mm and height of 16mm was machined using late machine and hacksaw. Each coupons was degreased by washing in ethanol, dried in acetone and kept in a desiccator. Weighed to obtain the weight difference before insert into beaker. The coupons were immersed in different media by means of a nylon thread that was hung on a retort standard tied to the coupons. Samples of the mild steel were inserted into the beakers and allowed to stand for 28 days (672 hours) with a set withdrawn after every 7 days (168 hours). 60g of extracts from *Dioscorea rotundata* (yam), *Manihot esculenta* (cassava) and *Zea mays* (maize) were obtained respectively using standard laboratory procedures. Volumetric concentrations of the leaves extracts were expressed in cubic centimeter(cm^3). The concentrations of *Dioscorea rotundata*, *Manihot esculenta* and *Zea mays* leaves extracts used for this study were of 5cm^3 while, the concentration of the acid, alkali and salt were 0.5M and 1.0M respectively. A total of sixty (60) beakers were thoroughly washed and rinsed with distilled water and air dried before the setup of the experiment so as to avoid additional water.

RESULTS AND DISCUSSION

Results

Table 1 to 6 accordingly, represent the results obtained for the variation of corrosion rate with exposure time for the mild steel specimen immersed in 0.5M and 1.0M of NaOH, NaCl and H_2SO_4 with 5cm^3 of leaves extracts of yam, maize and cassava. While, Figures 1 to 6 show the various variation of corrosion rate with exposure time for the corrosion of mild steel with 5cm^3 of leaves extracts of yam, maize and cassava for 0.5M and 1.0M of NaOH, NaCl and H_2SO_4 respectively.

Table 1: Yam, Maize and Cassava Leaves Extract in 0.5M NaOH

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR (mm/yr)
Control				
5cm^3 (Y)				
168	9.07	8.67	0.40	0.00047
336	9.39	9.01	0.38	0.00022
504	9.32	9.12	0.20	0.00008
672	9.54	9.34	0.20	0,00006
5cm^3 (M)				
168	9.11	8.53	0.58	0.00069
336	9.52	8.98	0.54	0.00032
504	9.54	9.02	0.52	0.00021
672	9.02	8.52	0.50	0.00015
5cm^3 (C)				
168	9.56	9.11	0.45	0.0005
336	9.52	9.12	0.40	0,0002
504	9.36	9.00	0.36	0.0001
672	9.41	9.13	0.28	0.0001

Table 2: Yam, Maize and Cassava Leaves Extract in 1.0M NaOH

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR (mm/yr)
Control				
5cm^3 (Y)				
168	9.67	8.96	0.71	0.00084
336	9.60	9.00	0.60	0.00036
504	9.59	8.98	0.61	0.00024
672	9.45	8.87	0.58	0.00017
5cm^3 (M)				
168	9.55	8.75	0.80	0.00095
336	9.52	8.71	0.81	0.00048
504	9.35	8.55	0.80	0.00032
672	9.31	8.53	0.78	0.00023
5cm^3 (C)				
168	9.47	8.69	0.78	0.0009
336	9.50	8.78	0.72	0.0004
504	9.23	8.59	0.64	0.0003
672	9.25	8.75	0.50	0.0001

Table 3: Yam, Maize and Cassava Leaves Extract in 0.5M NaCl

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR (mm/yr)
Control				
5cm^3 (Y)				
168	9.01	8.97	0.04	0.00005
336	9.96	9.92	0.04	0.00002
504	9.85	9.82	0.03	0.00001
672	9.82	9.80	0.02	0.00001
5cm^3 (M)				
168	9.20	9.14	0.06	0.00007
336	9.75	9.70	0.05	0.00003
504	9.75	9.70	0.05	0.00002
672	9.25	9.21	0.04	0.00001
5cm^3 (C)				
168	9.56	9.11	0.45	0.0005
336	9.52	9.12	0.40	0,0002
504	9.36	9.00	0.36	0.0001
672	9.41	9.13	0.28	0.0001

Table 4: Yam, Maize and Cassava Leaves Extract in 1.0M NaCl

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR (mm/yr)
Control				
5cm^3 (Y)				
168	9.20	9.13	0.07	0.00008
336	9.65	9.59	0.06	0.00004
504	9.77	9.71	0.06	0.00002
672	9.48	9.44	0.04	0.00001
5cm^3 (M)				
168	9.37	9.29	0.08	0.00009
336	9.26	9.18	0.08	0.00005
504	9.13	9.06	0.07	0.00003
672	9.25	9.19	0.06	0.00002
5cm^3 (C)				
168	9.79	9.74	0.05	0.00010
336	9.13	9.09	0.04	0.00002
504	9.66	9.62	0.04	0.00002
672	9.87	9.84	0.03	0.00001

Table 5: Yam, Maize and Cassava Leaves Extract in 0.5M H_2SO_4

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR (mm/yr)
Control				
5cm^3 (Y)				
168	9.42	8.86	0.56	0.00066
336	9.30	8.88	0.42	0.00025
504	9.18	8.75	0.43	0.00017
672	9.62	9.22	0.40	0.00012
5cm^3 (M)				
168	9.44	8.82	0.62	0.00073
336	9,03	8.41	0.62	0.00037
504	9.62	9.12	0.50	0.00020
672	9.20	8.77	0.43	0.00013
5cm^3 (C)				
168	9.32	8.72	0.60	0.00071
336	9.45	8.87	0.58	0.00034
504	9.40	8.90	0.50	0.00020
672	9.38	8.93	0.45	0.00013

Table 6: Yam, Maize and Cassava Leaves Extract in 1.0M H_2SO_4

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR (mm/yr)
Control				
5cm^3 (Y)				
168	9.96	9.14	0.82	0.00097
336	9.56	8.76	0.80	0.00047
504	9.32	8.52	0.80	0.00032
672	9.57	8.81	0.76	0.00022
5cm^3 (M)				
168	9.98	9.00	0.98	0.00116
336	9.58	8.72	0.86	0.00051
504	9.57	8.71	0.86	0.00034
672	9.58	8.85	0.73	0.00022
5cm3				
168	9.51	8.65	0.86	0.00102
336	9.66	8.82	0.84	0.00050
504	9.54	8.72	0.82	0.00032
672	9.64	8.84	0.80	0.00024

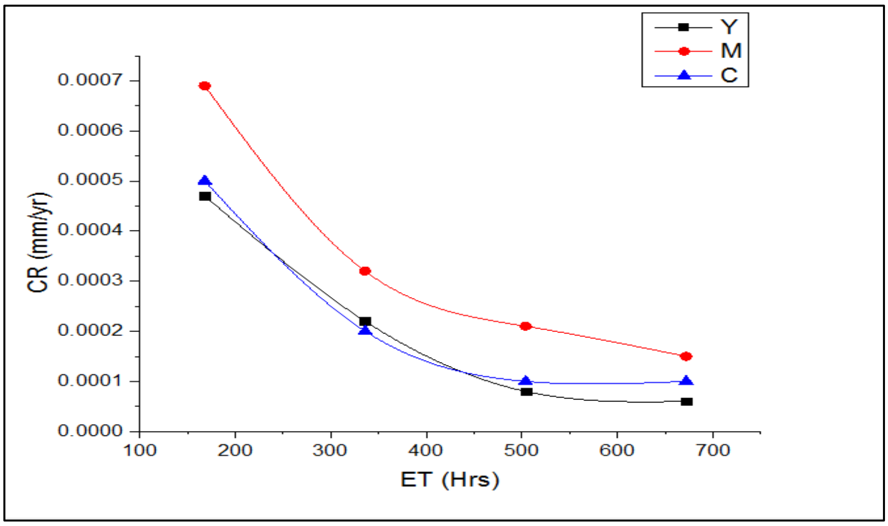

Figure 1: Variation of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 5cm^3 extracts of yam, maize and cassava for 0.5M of NaOH

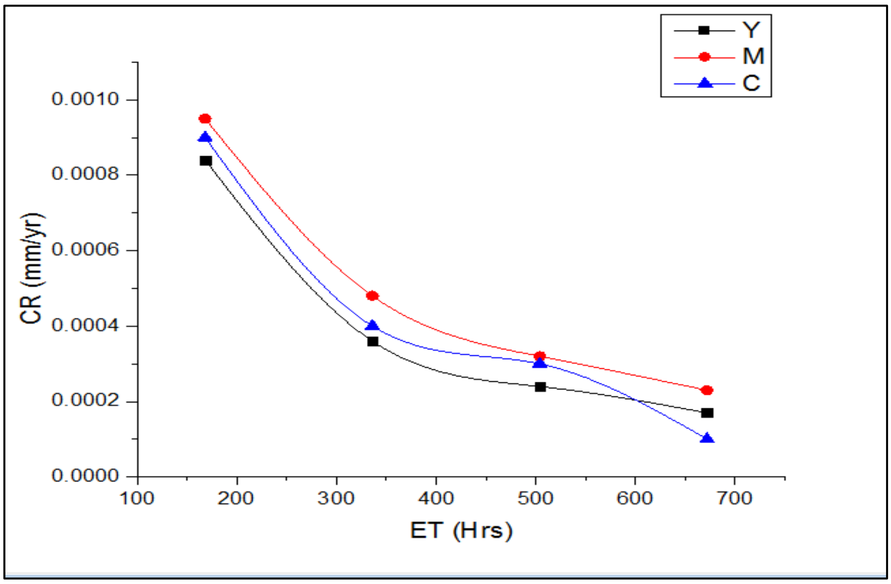

Figure 2: Variation of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 5cm^3 extracts of yam, maize and cassava for 1.0M of NaOH

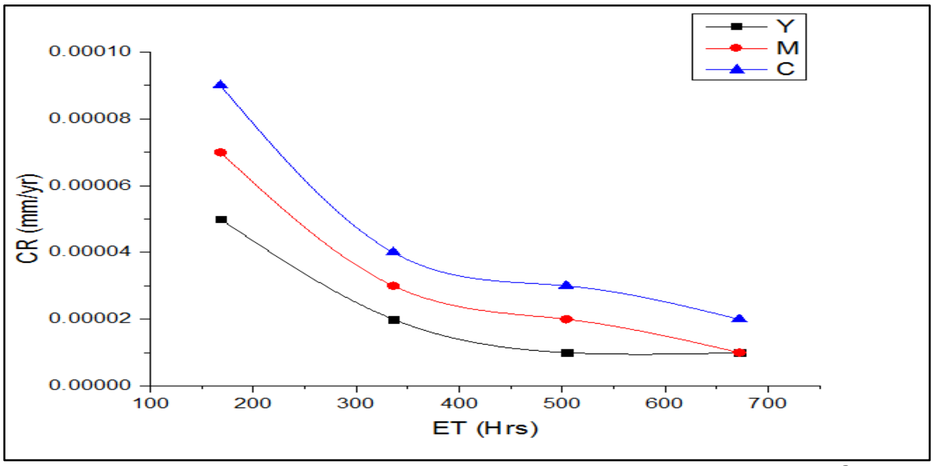

Figure 3: Variation of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 5cm^3 extracts of yam, maize and cassava for 0.5M of NaCl

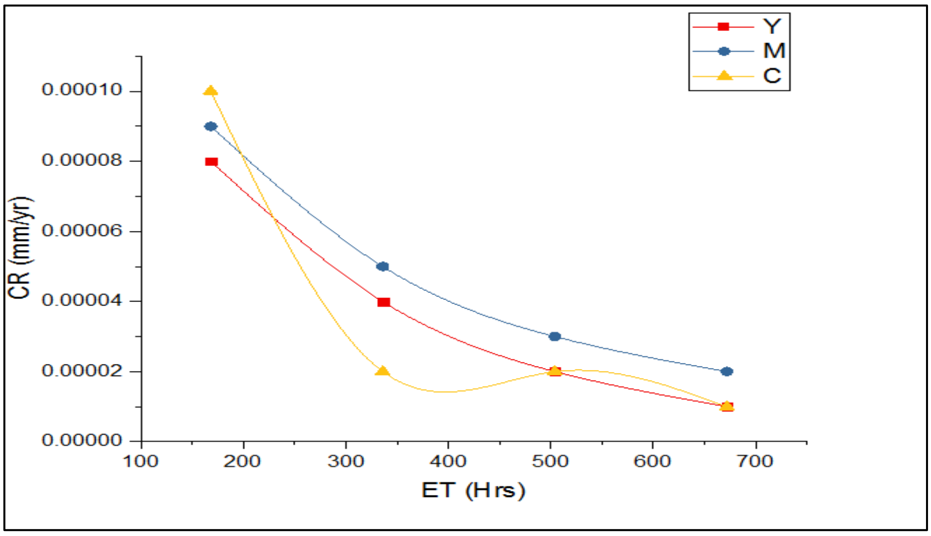

Figure 4: Variation of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 5cm^3 extracts of yam, maize and cassava for 1.0M of NaCl

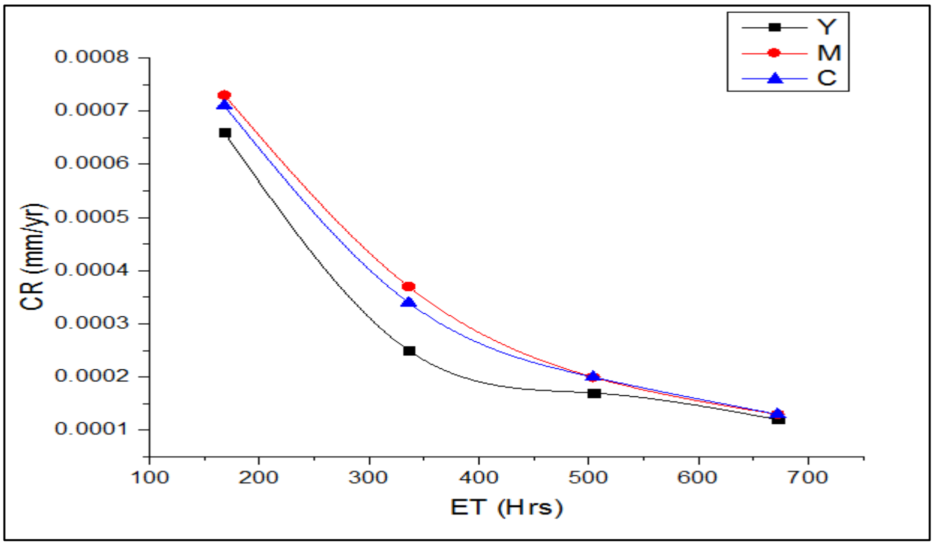

Figure 5: Variation of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 5cm^3 extracts of yam, maize and cassava for 0.5M of H_2SO_4

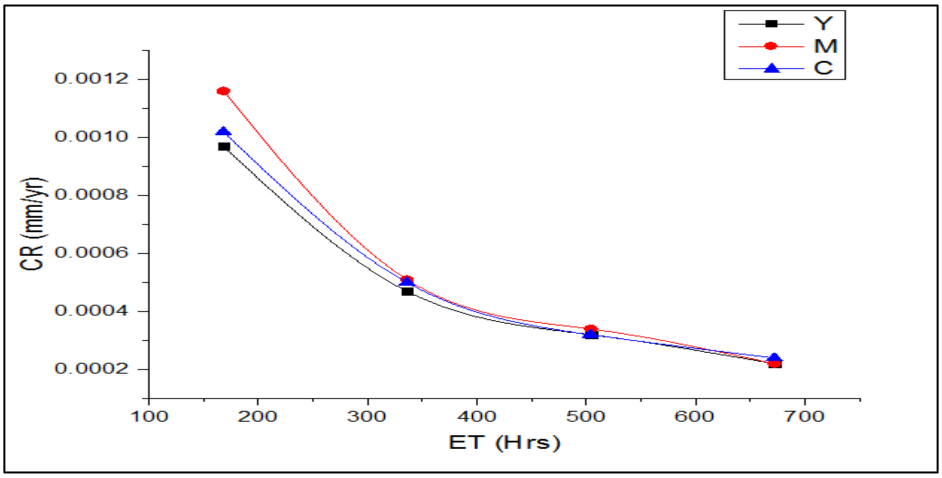

Figure 6: Variation of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 5cm^3 extracts of yam, maize and cassava for 1.0M of H_2SO_4

DISCUSSION

The results obtained for the variation of corrosion rates with exposure time for the mild steel specimens immersed in 0.5M and 1.0M of NaOH, NaCl and H_2SO_4 with 5cm^3 concentrations of *Dioscorea rotundata* (Yam), Zea *mays* (Maize) and Manihot *esculenta* (Cassava) leaves extracts are as presented in Figures 1 to 6. The result obtained show a high value of corrosion rate for the test media without leaves extract (Ifenyichukwu & Idenyi, 2023; Ifeanyichukwu & Nwifior, 2024). The addition of 5cm^3 leaves extracts of yam, maize and cassava to the test media resulted in reduction of corrosion rate. The *Dioscorea rotundata* (Yam) extracts shows a good inhibition behavior on the corrosion rate of mild steel in 0.5M and 1.0M of NaOH, NaCl and H_2SO_4 media. Followed by Manihot *esculenta* (Cassava) and Zea *mays* (Maize). These results are consistent with those reported by (Ifenyichukwu & Idenyi, 2023; Ifeanyichukwu & Nwifior, 2024; Obiukwu *et al.*, 2013). These results confirm that plant extracts of the *Dioscorea rotundata* (Yam), Zea *mays* (Maize) and Manihot *esculenta* (Cassava) possesses corrosion inhibiting property. It is not certain, however, whether the optimum concentration needed for more effective corrosion inhibition have been reached with any of the three concentrations used.

CONCLUSION

It can be concluded from the research findings that yam leaves, maize leaves and cassava leaves extracts are suitable for corrosion inhibition in an acidic, salt and alkaline environment. The leaves extracts of yam, maize and cassava act as good corrosion inhibitors and can be used to reduce the corrosion rate of mild steel if the appropriate concentrations are being used. Among the three plants extracts used, it was observed that *Dioscorea rotundata* (Yam) has the best inhibition efficiency in both alkaline, salt and acidic media, followed by *Manihot exculenta* (Cassava) and *Zea mays* (Maize) which also showed good inhibition efficiency. The results show the very good potentialities of the leaves extracts for application in our various manufacturing industries.

REFERENCES

- Calverly (1998). Storage and Processing of Roots and Tubers in Tropics. United Nations Food and Agriculture Organization.
- Doebley J. (2004). The genetics of maize evolution. Annual Reviews of Genetics. *38*, 37–59.
- Dumont, R. & Vernier, P. (2000). Domestication of yams (Dioscorea cavenensis-rotundata) within the Bariba ethnic group in Benin. Outlook on Agriculture. 29(2):137.
- Idenyi, N.E., Nwofe, P.A., & Idu, H.K. (2015). Influence of moringa oleifera and psidiurn guavaja leaves extract on the corrosion susceptibility of mild steel in an alkaline medium. *Journal of Applied Science Research, 11(22): 158-163.*
- Ifeanyichukwu, B. J. & Nwifior, K. (2024). Inhibition characteristics of locally maize leaf extracts as a good corrosion inhibitor in selected media. *International Journal of Research and Sustainable Development, 10(1), 7-16.* www.panafricanjournal.org
- Ifeanyichukwu, B. J.**,** Idu, H. K. & Idenyi, N. E. (2023). Inhibitive effect of locally dioscorea spp leaf extracts as a green corrosion inhibitor in selected media. *Journal of Material and Environmental Science,* 14(6), 702-710. http://www.jmaterenvironsci.com
- Ji, G., Shadma, A., Shanthi S., & Rajiv, P. (2015). Musa paradisica peel extract as green corrosion inhibitor for mild steel in HCl solution." *Corrosion Science 90*, 107-117.
- Kay, D. E. (1987). Root Crops London, UK: Tropical Development and Research Institute.
- Mourya, P., Banerjee, S., & Singh, M. M. (2014). Corrosion inhibition of mild steel in acidic solution by tagetes erecta (marigold flower) extract as a green inhibitor. *Corrosion Science*, *85*, 352-363

- Nora Scarcelli *et al*., (2019). Yam genomics supports Weast Africa as a major cradle of crop domestication. Science Advances. 5(5).
- The American Heritage Dictionary of the English Language, Fifth Edition. *Later, in the 17th century, another term for maize appears, Indian corn—the word Indian here meaning "native to the Americas." The American word corn in the specific meaning "maize" is simply a shortening of Indian corn.*
- Winch, J. E., Newhook, F. J., Jackson, G. V. H. & Cole, J. S. (1984). Studies of Colletotrichum gloeosporioides disease on yam, Dioscorea alata, in Solomon Islands. Plant Pathology. *33*(4): 467-477.