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Original Research Article

The Corrosion Patterns and Variations of Leaves Extracts of Yam, Maize and Cassava on Mild Steel in Simulated Corrosion Environments

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Abstract

The investigation of the inhibiting patterns and variations of $10cm^3$ leaves extracts of yam, maize and cassava 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 different concentrations of NaOH, NaCl and H_2SO_4 solutions with the $10cm^3$ leaves extracts alongside the control samples immersed in solution of the media without leaves extracts. The arrangements were allowed to stand for 672 hours and a set of samples from each environment withdrawn at intervals of 168 hours for corrosion characterization.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 $10cm^3$ leaves extracts introduced into the media thereby confirming that the leaves extracts functioned as effective and excellent inhibitors in the NaOH, NaCl and H_2SO_4 media. Among the leaves extracts from the three plants used, it was observed that Yam has the best inhibition efficiency in both NaOH (alkaline), NaCl (salt) and H_2SO_4 (acidic) media, followed by Cassava and Maize which also showed good inhibition efficiency. The results show the very good potentialities of the leaves extracts for application in the diminution of corrosion in our various manufacturing industries.
Keywords: Corrosion, Inhibiting Patterns, Leaves Extracts, Mild Steel.

INTRODUCTION

The applications of the new green inhibitors have continued to gain interest in the technological world. In the field of material science and corrosion control, scientists are recurrently seeking the better and the more efficient ways of combating the corrosion of metals (Ifeanyichukwu *et al.*, (2023); Ifeanyichukwu and Nwifior, 2024; Idenyi, Nwofe and Idu, 2015).

The deleterious consequences of corrosion in industries are well known (Ifeanyichukwu & Nwifior, 2024; Ifeanyichukwu *et al.*, (2023); Jamiu & Olorunfemi, 2013) leading to 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 *et al.*, (2023); Ifeanyichukwu and Nwifior, 2024; Jl Shadma, Shanthi and Rajiv, 2015).

The use of industrial chemicals like acids, hydroxide and salts are diverse and frequent. For instance, solutions of tetraoxosulphate (vi) acid are used for the removal of rusts, industrial cleaning, descaling and oil well acidifying among others. NaCl is used for example in the production of industrial chlorine and in road de-icing; while on the other hand NaOH is used in paper making and in the manufacturing of soaps and detergents. These activities expose metals in contact with the chemicals to sever corrosion damage over time hence the need to eliminate or minimize the influence to permissible limits.

Yam:

This is believed to have originated in Central and South America around 8000 BC, a time when the leaves of the plant were manly utilized for their medicinal purposes. Today yam leaves are most commonly used in African and Asian cuisines. Yams thrive in tropical and subtropical climates and do well in both sunny and shady growing conditions provided the soil is kept moist (Ifeanyichukwu *et al.,* (2023). In spite of the potential, the study of the application of yam leave extracts in corrosion inhibition is still mostly unexplored.

Maize:

This is a tall, monoecious annual grass with overlapping sheaths and broad conspicuously distichous blades. Maize plants have staminate spikelets in long spike-like racemes that form large spreading terminal panicles (tassels) and pistillate inflorescences in the leaf axils, in which the spikelets occur in 8 to 16 rows, approximately 30 cm long, on a thickened, almost woody axis (cob). The whole structure (ear) is enclosed in numerous large foliaceous bracts and a mass of long styles (silks) protrude from the tip as a mass of silky threads (Ifeanyichukwu and Nwifior, 2024).

Maize has been a fruitful model organism for research in genetics for many years but its application in corrosion engineering studies remains largely limited in scope.

Cassava:

This 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.

Cassava varieties are generally distinguished from each other by their morphological characteristics which include leaf, stem and tuber color, leaf shape and number of storage roots per plant. These characrostic features may very well affect its behavior when employed in corrosion studies.

Giving that, the whole idea of metal protection is anchored on economic gain and environmental sustainability, the substance to be used as metal corrosion inhibitor must be cheap, readily available, and environmentally friendly. Hence, the use of the leaves of yam, maize and cassava. Current research activities are geared towards finding a replacement for inorganic metal corrosion inhibitors. Thus, leaf is one of the sources of cheap, readily available, and non-toxic green metal corrosion inhibitors.

Leaf Products are organic in nature, and contain certain photochemical substances such as: tannins, flavonoids, saponins, organic and amino acids; alkaloids, and pigments which could be extracted by simple less expensive procedures. Extracts from different parts of leaves have been widely reported as effective and good metal corrosion inhibitors in various corrosive media (Nnanna, Nnakaife, Ekekwe and Eti, 2016).

This work therefore seems to further extend the frontiers of research knowledge in the continuously evolving field of corrosion monitoring and control using green inhibitors.

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 (cm3). The concentrations of Dioscorea rotundata, Manihot esculenta and Zea mays leaves extracts used for this study were of 10cm3 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 DISCUSISON

Results

Tables 1 and 2 represents the Yam, Maize and Cassava Leaves Extract of $10cm^3$ in 0.5M and 1.0M NaOH. Tables 3 and 4; the Yam, Maize and Cassava Leaves Extract of $10cm^3$ in 0.5M and 1.0M NaCl. Tables 5 and 6; the Yam, Maize and Cassava Leaves Extract of $10cm^3$ in 0.5M and 1.0M H_2SO_4. While, Figures 1, 2, 3, 4, 5 and 6; show the various patterns of corrosion rate with exposure time for the corrosion of mild steel with $10cm^3$ 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 of 10cm^3 in 0.5M NaOH

Media/Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight Difference (g)	CR(mm/yr)
Control				
168	9.52	8.70	0.82	0.0010
336	9.50	8.86	0.64	0.0004
504	9.48	8.84	0.64	0.0003
672	9.42	8.90	0.52	0.0002
10cm^3 (Y)				
168	9.08	8.74	0.34	0.00040
336	9.61	9.39	0.22	0.00013
504	9.62	9.42	0.20	0.00008
672	9.69	9.59	0.10	0.00003
10cm^3 (M)				
68 1	9.25	8.74	0.51	0.00060
336	9.11	8.61	0.50	0.00030
504	9.09	8.59	0.50	0.00020
672	9.10	8.62	0.48	0.00014
10cm^3 (C)				
168	9.32	8.90	0.42	0.0005
336	9.43	9.15	0.30	0.0002
504	9.51	9.21	0.30	0.0001
672	9.12	8.92	0.20	0.0001

Table 2: Yam, Maize and Cassava Leaves Extract of 10cm^3 in 1.0M NaOH.

Media/ Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR(mm/yr)
Control				
168	9.13	8.19	0.94	0.00111
336	9.71	8.91	0.80	0.00041
504	9.66	8.96	0.70	0.00028
672	9.78	9.08	0.70	0.00021
10cm^3 (Y)				
168	9.58	9.15	0.43	0.00051
336	9.42	9.04	0.38	0.00022
504	9.44	9.07	0.37	0.00015
672	9.32	8.98	0.34	0.00010
10cm^3 (M)				
168	9.24	8.50	0.74	0.00088
336	9.67	8.94	0.73	0.00043
504	9.88	9.18	0.70	0.00028
672	9.32	8.72	0.60	0.00018
10cm^3 (C)				
168	9.52	8.99	0.53	0.0006
336	9.45	9.05	0.40	0.0002
504	9.44	9.04	0.40	0.0002
672	0.26	8.90	0.36	0.0001

Table 3: Yam, Maize and Cassava Leaves Extract of 10cm^3 in 0.5M NaCl Solution.

Media/Exposure time(Hrs)	Initial Weight (g)	Final Weight (g)	Weight difference (g)	CR (mm/yr)
Control				
168	9.52	9.46	0.06	0.00007
336	9.39	9.34	0.05	0.00003
504	9.43	9.39	0.04	0.00002
672	9.65	9.61	0.04	0.00001
10cm^3(Y)				
168	9.80	9.77	0.03	0.00004
336	9.32	9.30	0.02	0.00001
504	9.67	9.64	0.03	0.00001

672	9.20	9.19	0.01	0.000004
10cm^3(M)				
168	9.08	9.04	0.04	0.00005
336	9.08	9.05	0.03	0.00002
504	9.22	9.20	0.02	0.00001
672	9.16	9.13	0.03	0.00001
10cm^3(C)				
168	9.71	9.64	0.07	0.00008
336	9.51	9.45	0.06	0.00004
504	9.47	9.40	0.07	0.00003
672	9.48	9.43	0.05	0.00001

Table 4: Yam, Maize and Cassava Leaves Extract of 10cm^3 in 1.0M NaCl Solution.

Media/ Exposure Time (Hrs)	Initial weight(g)	Final weight (g)	Weight difference (g)	CR(mm/yr)
Control				
168	9.26	9.17	0.09	0.00011
336	9.31	9.23	0.08	0.00005
504	9.43	9.35	0.08	0.00003
672	9.45	9.38	0.07	0.00002
10cm^3 (Y)				
168	9.70	9.65	0.05	0.00006
336	9.46	9.42	0.04	0.00002
504	9.87	9.82	0.05	0.00002
672	9.46	9.43	0.03	0.00001
10cm^3 (M)				
168	9.M1	9.04	0.07	0.00008
336	9.06	9.00	0.06	0.00004
504	9.15	9.10	0.05	0.00002
672	9.31	9.26	0.05	0.00001
10cm^3 (C)				
168	9.24	9.20	0.04	0.00005
336	9.97	9.94	0.03	0.00002
504	9.03	9.94	0.02	0.00001
672	9.89	9.87	0.02	0.00001

Table 5: Yam, Maize and Cassava Leaves Extract of 10cm^3 in 0.5M H_2SO_4.

Media / Exposure time (Hrs)	Initial weight (g)	Final Weight (g)	Weight difference (g)	CR(mm/ yr)
Control				
168	9.99	6.74	2.81	0.00333
336	9.49	7.76	1.73	0.00102
504	9.38	8.42	0.96	0.00038
672	9.42	8.53	0.89	0.00026
10 cm^3 (Y)				
168	9.02	8.61	0.41	0.00049
336	9.16	8.78	0.38	0.00022
504	9.25	8.89	0.36	0.00014
672	9.51	9.17	0.34	0.00010
10cm^3(M)				
168	9.10	8.58	0.52	0,00062
336	9.22	8.73	0.49	0.00029
504	9.25	8.82	0.43	0.00017
672	9.75	9.39	0.36	0.00011
10cm^3(C)				
168	9.35	8.83	0.52	0.00062
336	9.41	8.98	0.43	0.00025
504	9.42	9.03	0.39	0.00015
672	9,40	0.05	0.35	0.00010

Table 6: Yam, Maize and Cassava Leaves Extract of 10cm^3 in 1.0M H_2SO_4.

Media/Exposure time (Hrs)	Initial weight (g)	Final weight (g)	Weight difference (g)	CR(mm/yr)
Control				
168	9.42	5.99	3.43	0.00406
336	9.85	6.90	2.95	0.00175
504	9.63	8.06	1.57	0.00062
672	9.88	8.40	1.40	0.00041
10cm^3(Y)				
168	9.27	8.67	0.60	0.00071
336	9.73	9.11	0.62	0.00037
504	9.11	8.51	0.60	0.00024
672	9.78	9.78	0.58	0.00017
10cm^3(M)				
168	9.48	8.64	0.84	0.00099
336	9.51	8.81	0.70	0.00041
504	9.37	8.69	0.68	0.00027
672	9.28	8.64	0.64	0.00019
10cm^3(C)				
168	9.60	8.90	0.70	0.00083
336	9.61	8.93	0.68	0.00040
504	9.49	8.89	0.60	0.00024
672	9.50	8.90	0.60	0.00018

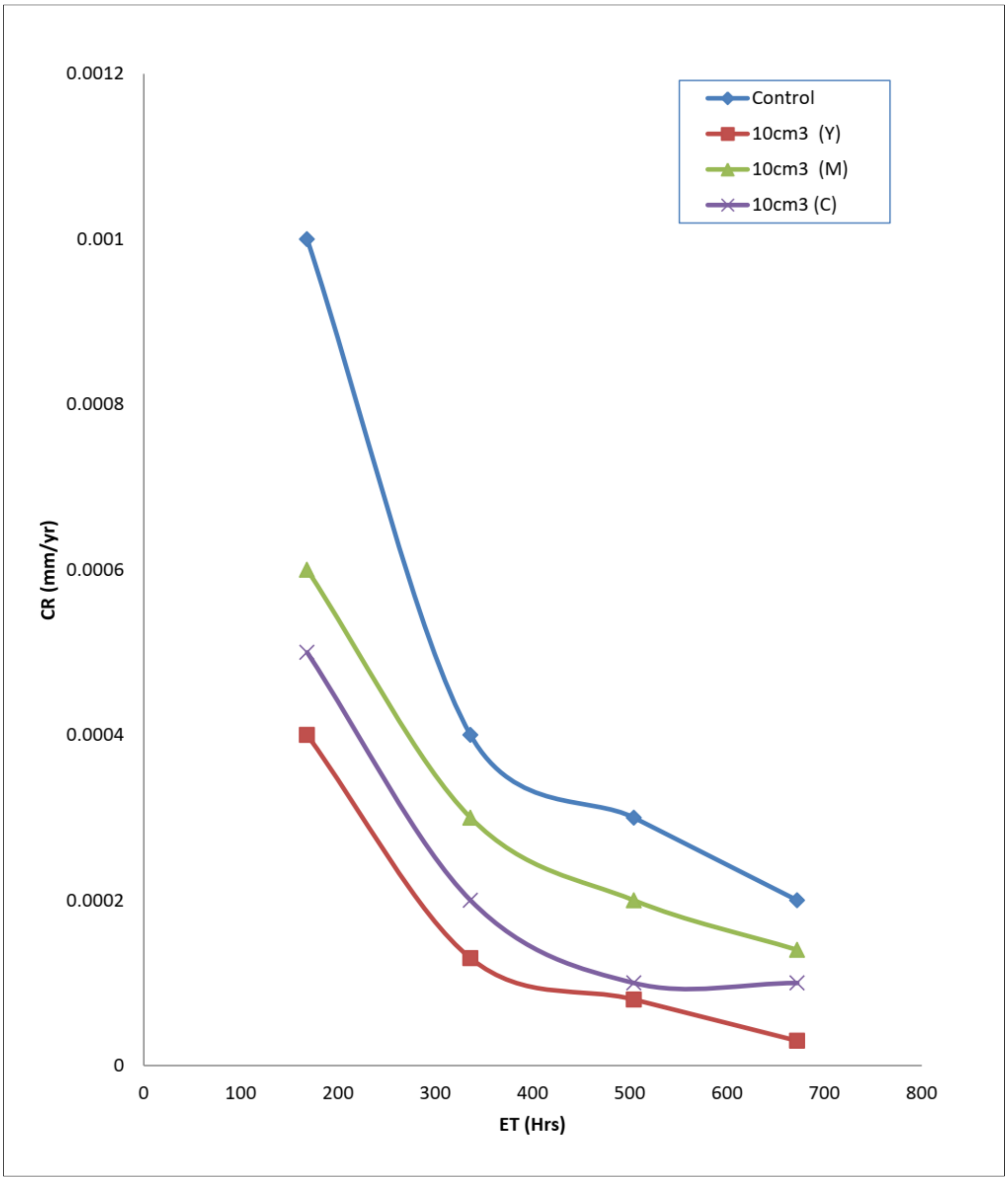

Figure 1: Patterns of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 10cm^3 of leaves extracts of yam, maize and cassava for 0.5M of NaOH

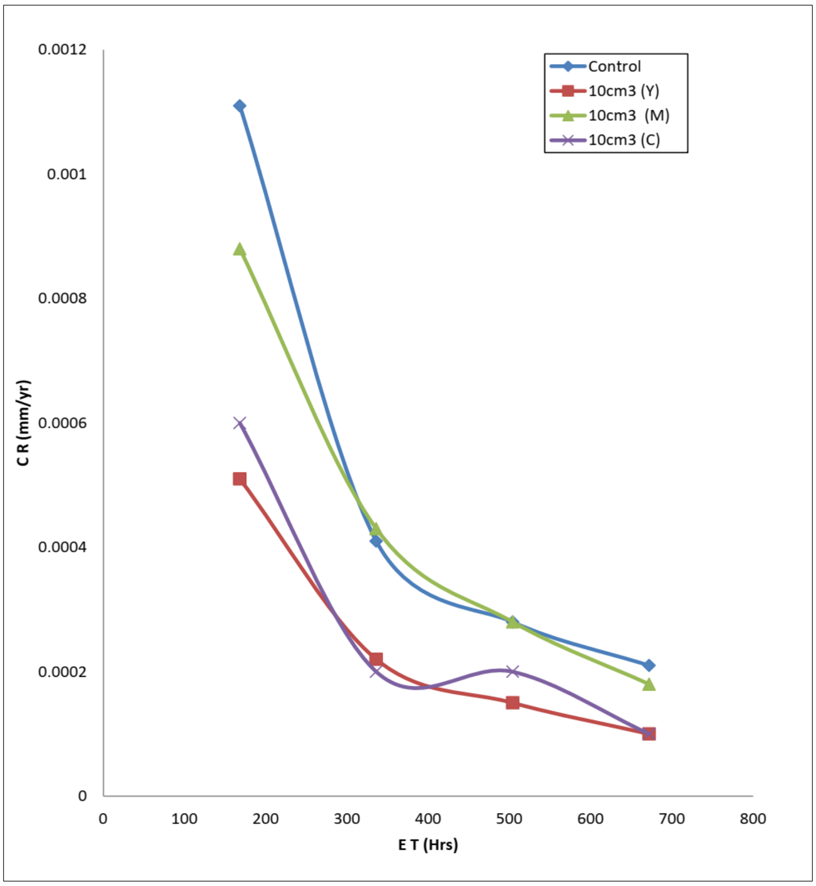

Figure 2: Patterns of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 10cm^3 of leaves extracts of yam, maize and cassava for 1.0M of NaOH

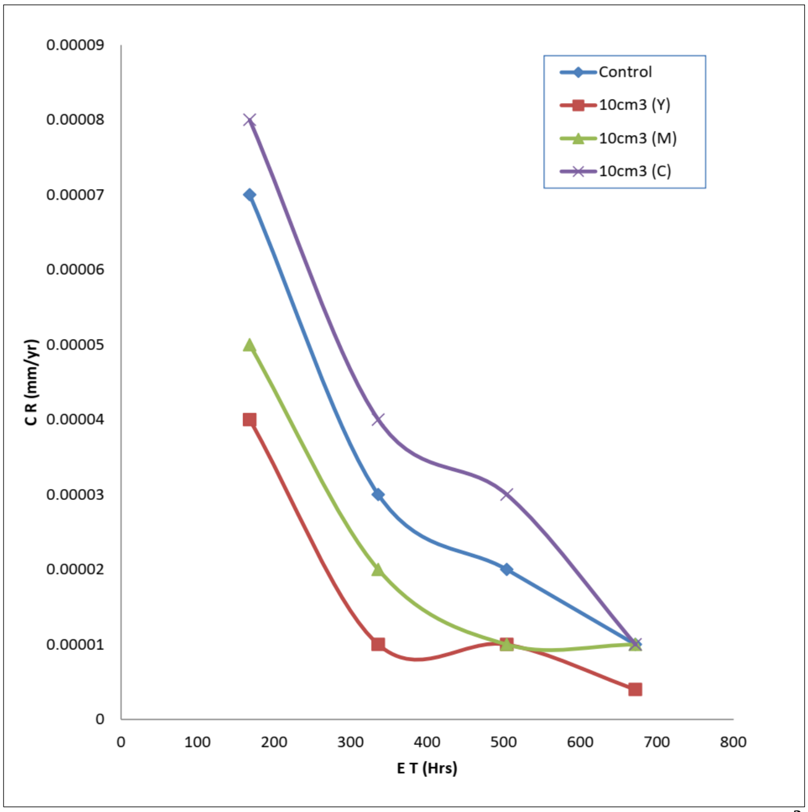

Figure 3: Patterns of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 10cm^3 of leaves extracts of yam, maize and cassava for 0.5M of NaCl

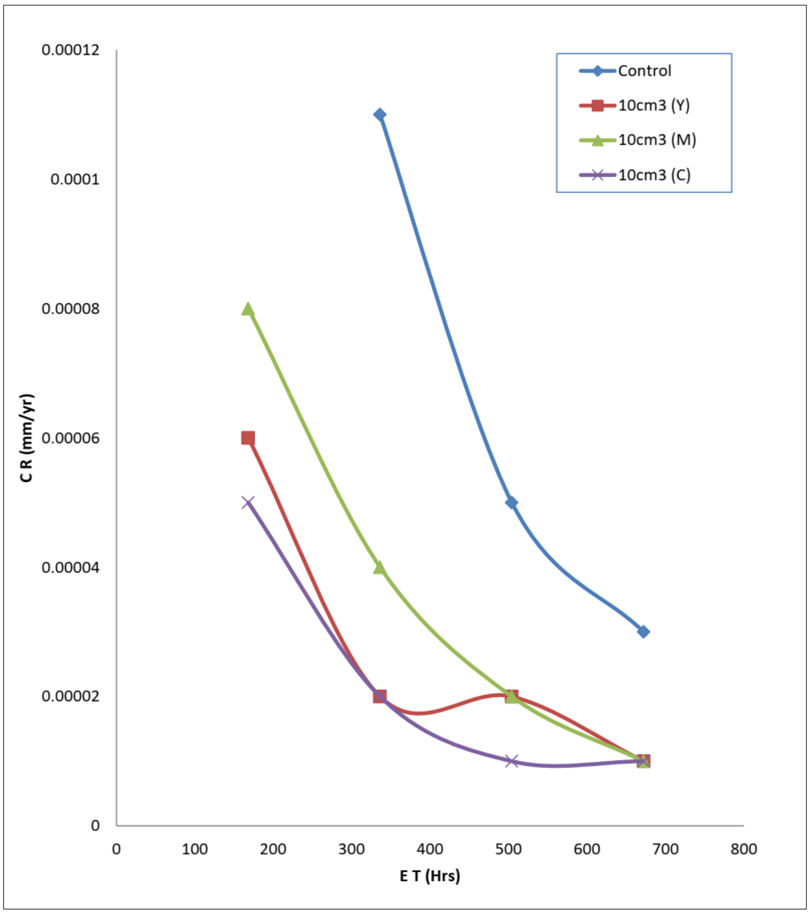

Figure 4: Patterns of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 10cm[3] of leaves extracts of yam, maize and cassava for 1.0M of NaCl

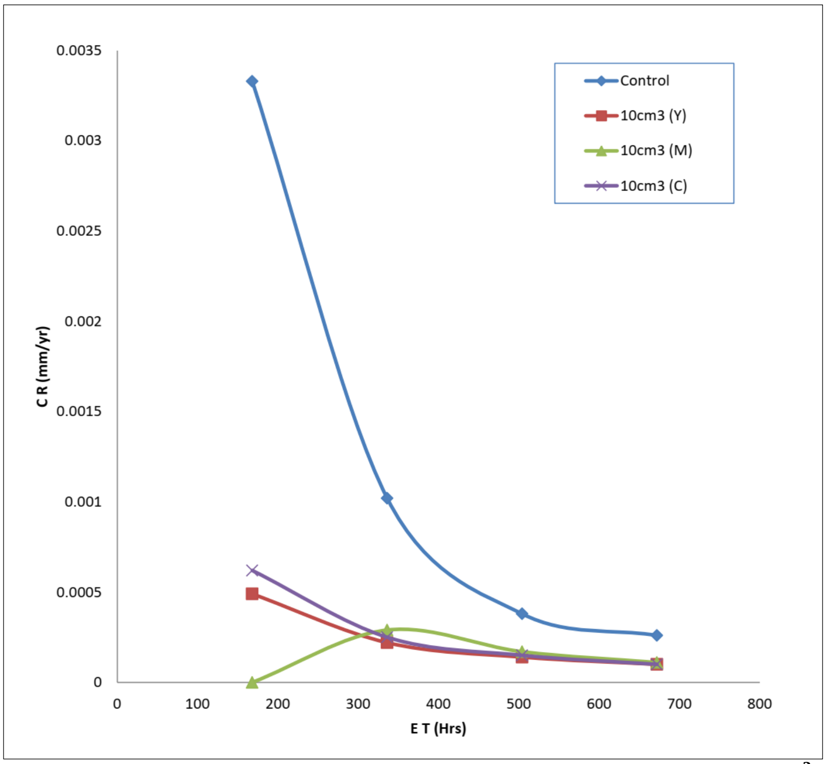

Figure 5: Patterns of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 10cm[3] of leaves extracts of yam, maize and cassava for 0.5M of H_2SO^4

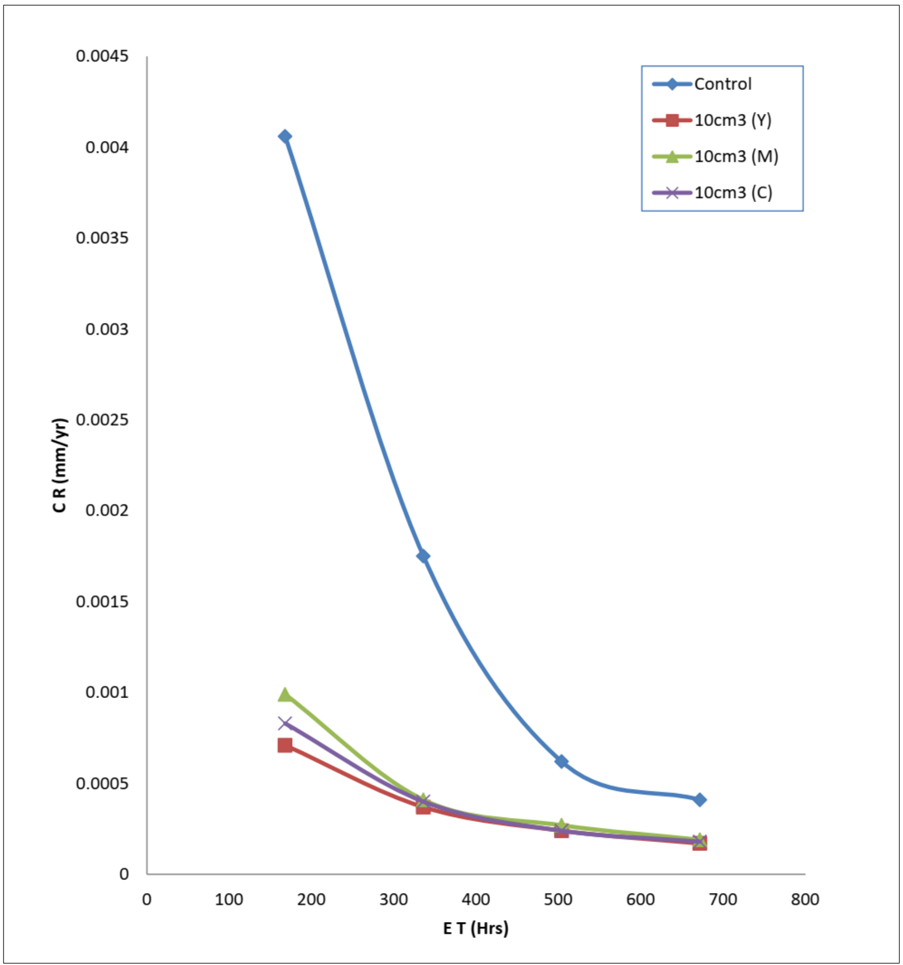

Figure 6: Patterns of CR (mm/yr) with ET (Hrs) for the corrosion of mild steel with 10cm^3 of leaves extracts of yam, maize and cassava for 1.0M of H_2SO_4

DISCUSSION

The results obtained for the patterns and variations 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 10cm^3 concentrations of leaves extracts of Yam, Maize and Cassava are as represented in Figures 1, 2, 3, 4, 5 and 6. It is evident from the graphs that the corrosion rate profile for passivating metals were noticed, characteristically with an initial steep rise in corrosion rate and progressive decline as exposure time increased. The outcomes show a high value of corrosion rate for the test media without leaves extract. The addition of 10cm^3 leaves extracts of yam, maize and cassava to the test media epatterns on the corrosion rate of mild steel in 0.5M and 1.0M of NaOH, NaCl and H_2SO_4 solution, succeeded by cassava and maize. These results are consistent with those reported by Ifeanyichukwu *et al.*, 2023. Ifeanyichukwu & Nwifior, 2024; and Obiukwu *et al.*, 2013). These results confirmed that, the leaves extracts of Yam, Maize and 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

From the research findings, it can be concluded that yam leaves, maize leaves and cassava leaves extracts are suitable for corrosion inhibition in NaOH, NaCl and H_2SO_4. Among the three leaves extracts used, it was observed that yam leaves extracts has the best inhibition efficiency in both alkaline, salt and acidic media, followed by cassava and maize which also showed good inhibition efficiency. The results show the very good potentialities of the three leaves extracts for application in our various manufacturing industries.

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