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THE INHIBITIVE PERFORMANCE OF WATERMELON RIND ON THE CORROSION BEHAVIOR OF MILD STEELS IN 0.5 M H_2SO_4

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Abstract

The watermelon rind extract molecules are used in the inhibition of API 5L steel in 0.5 M H_2SO_4 solution. Watermelon is an agro waste which is being discarded after the fleshy part has been consumed which causes environmental pollution. The rind is one of the possible ways for green chemistry and sustainable of protecting API 5L steel used in petrochemical environments from corrosion. The corrosion test utilized in this research is weight loss and polarization techniques. The results showed that watermelon rind is an effective inhibitor in 0.5 M H_2SO_4. The results showed an optimum inhibition efficiency of 99.9% at 4% of the inhibitor concentration which is still retained at 5% for the polarization test. The weight loss experiment shows the highest inhibition efficiency of 84% at 3% of the inhibitor concentration. The inhibition efficiency could be attributed to the presence of organic compounds and functional groups present in the extract which was shown with the aid of the elemental analysis, phytochemical analysis and the Fourier Transform Infrared Spectrum.

Keywords: Inhibitor, Watermelon Rind, Corrosion, Polarization Analysis; Phytochemical Analysis

1.0 Introduction

Steel is the name for a versatile group of iron-carbon alloys. The carbon content of steels ranges from few hundredths percent to about 1 percent. Steels contain varying amounts of other elements like manganese, silicon, phosphorous, sulfur and other trace elements which contribute to its overall property (Huyett, 2000). More than 80% of the steels used for engineering applications are made up of mild steel, because of its cost effectiveness, toughness, ductility and ease of manufacture (Sultana *et al*., 2014).

Currently, the adverse effect of corrosion – a natural phenomenon which transforms a refined metal into a more chemically stable form, has vastly contributed to various engineering failures around the world (Anadebe *et al*., 2020; Etim *et al*., 2019). Steels are being exposed to aggressive environments during their service life. Aggressive environments such as acids which is used in many industrial processes such as Sulphuric acid in the production of fertilizers, dyes, drugs and organic salts, petroleum refining and metallurgical processes (Olaseinde *et al.*, 2019). Limitations such as capital and operating costs, reliability and possible future restrictions based on environmental considerations are what made corrosion inhibition the preferred choice of all forms of corrosion control (Salama, 2004; Pratikno *et al*., 2018). Despite the good properties, researches on inorganic inhibitors have revealed that they are costly and toxic to the environment. Currently, sustainability initiatives that use green chemistry to recover and safeguard our global environment are crucial concerns in many fields of research. This necessitates the need for a cleaner, eco-friendly and less expensive inhibitor as a globally acceptable way of mitigating corrosion (Ahmad and Sharma, 2012; Iyaguchi *et al*., 2010).

Organic inhibitors because of their non-toxic, sustainable and ecofriendly nature have found applications in different fields of corrosion control. Some of the extracts that have been used for organic inhibitors include sweet potato, orange peels, moringa leaves, cashew nut, garlic, yeast, pepper, coffee seeds and water melon rind (Ghaffarinejad *et al*., 2016).

Researchers like Hemapriya *et al.*,(2020) have worked on the utilization of bio-waste as an eco-friendly biodegradable corrosion inhibitor for mild steel in an acidic environment, the results revealed that the corrosion inhibitor is efficient for mitigating against corrosion via adsorption on the metal surface with a mix-mode corrosion inhibition behavior. The research in the area of corrosion inhibition have mostly considered inhibition on a general basis and are yet to do research on the individual components responsible for the inhibitive characteristics exhibited. This investigation is to improve on the prevailing researches on the use of water melon rind as organic inhibitor.

2.0 Methods and Procedures

2.1 Materials Used

This research was conducted in The Federal University of Technology, Akure which are Advanced Materials and Electrochemical Research Group Laboratory and Central Research Laboratory, FUTA. The materials used for the research were mild steel – API 5L steel, watermelon (*Citrullus lanatus*) rind extract, Tetraoxosulphate (VI) H_2SO_4 acid, Distilled Water and Filter Paper.

2.2 Preparation of Watermelon Rind Extract

The watermelon rind was obtained from a watermelon sales store, washed and cut into small bits, then the water melon was oven dried at 110°C in an oven. The dried water melon was grounded, the extract of the watermelon rind was prepared by boiling the extract in distilled water. The solution was cooled and filtered to get various concentration of watermelon rind extract. 0% (control group), 1%, 2%, 3%, 4% and 5%. The concentrations are used for each of the three corrosive environments (0.5M H_2SO_4).

2.3 Metal Preparation

The API 5L steel was cut into square sized coupons of 1cm by 1cm by 0.6cm dimension. Each coupon was abraded with silicon carbide abrasive papers of grades 60 to 1200 using a polishing machine and rinsed with distilled water. The residue of the polishing process was removed by degreasing with ethanol. The metal specimen used for the potentiodynamic polarization is prepared by mounting the steel with polyester resin at room temperature and the surface was polished to remove any mill scale.

2.4 Extract Characterization

Characterizations of the extracts were carried out using Atomic adsorption spectroscopy (AAS), phytochemical analyzer and Fourier Transform Infrared Spectroscopy (FTIR). The main aim of characterization is for the identification of the elements, functional groups and structures in the extract.

3.0 Results and Discussion

3.1. Elemental analysis

The results in table 2 shows that the extract contains anticorrosive elements in sufficient quantities which makes watermelon rind a good corrosion inhibitor.

3.2 Phytochemical Analysis

The result of the phytochemical tests in Table 3 shows the watermelon rind contains several heteroatoms and covalent-bond organic compounds like Saponins, Alkaloids, Flavonoids, Terpernoids, Tanins and Phenols. This phytochemicals display anticorrosive properties through an ionic interaction with the metal surface, this shows watermelon is a good inhibitor. The results agrees with the previous works on watermelon rind as a corrosion inhibitor (Nahusona and Koriston, 2019; Odewumi *et al*., 2014).

3.3 Fourier Transform Infrared (FTIR) Result

The results of the FTIR experiment could be interpreted according to Nandiyanto *et al.,* (2019). From Figure 1 and Table 4, the spectrum of the watermelon rind shows a peak at wavelength of 3317.3 a functional group of Acetylenic-Alkyne C-H stretch. The second peak is at 2094.8 which shows Nitrogen multiple and cumulated double bond compound of Isothiocyanathe (-NCS). The third peak is at 1640.0 which is a simple hetero-oxy compound (nitogen-oxy compounds) of organic nitrates. The fourth peak is at 1088.4 showing silicon-oxy compounds of organic siloxane or silicone (Si-O-Si). The fifth peak is at 607.6 shows the thiols and the thio-subsituted compounds of disulfides (S-S stretch). The last peak was obseerved at 432.4 showing aryl disulfides (S-S stretch) in the watermelon rind. All the peaks in the extract shows that water melon rind is a good inhibitor.

3.4 Weight Loss

Figure 2 shows the inhibition efficiency of watermelon rind for API 5L steel in 0.5M H_2SO_4 using weight loss method. It can be seen from the graph that the rate of corrosion is time dependent. The corrosion rate reduces with increase in the concentration of the inhibitor in the acidic environment.

Table 5 shows the corrosion rate of API 5L steel with and without watermelon rind extract for a period of 720 hours in 0.5 M H_2SO_4. The corrosion rate reduces with increase in the inhibitor concentration in the sulphuric acid environment. The highest inhibitor concentration is for 3% inhibitor concentration with 84% efficiency.

Figure 3 and Table 6 shows the data for the polarization of API 5 steel in 0.5 M H_2SO_4 with and without watermelon rind as inhibitor. From the data obtained in Table 6, the uninhibited sample has the lowest polarization resistance, the highest corrosion density and corrosion rate. The corrosion rate of the metal decreases with increasing concentration of the inhibitor. The decrease in corrosion rate from 4% shows only little difference with increasing concentration as the inhibition efficiency attained the peak value 99.9% at 4% and retains it even with increasing inhibitor concentration of 5%. This shows watermelon rind is a good inhibitor for API 5 steel in a sulphuric environment.

Table 1: Chemical Composition of the API 5L used

C	Si	Mn	P	Nb	Cr	Mo	Ni	Al	Fe
0.157	0.279	1.280	0.0213	0.0380	0.0248	0.0031	0.0220	0.0381	Bal.

Table 2: The Atomic Absorption Spectroscopy for Water Melon Rind.

Sample (ppm)	Ca	Fe	Cu	Mn	K	Na	Zn
Rind	1712.00	36.00	17.00	17.50	44732.00	4752.00	59.50

Table 3: The Phytochemical Analysis Results for Water Melon Rind.

Sample	Saponin (%)	Alkaloids (%)	Flavonoids (mg/100g)	Terpenoids (mg/100g)	Tanin (mg/100g)	Phenols (mg/100g)
	3.04	6.10	0.10	0.93	0.48	0.32

Table 4: The Wavelenth and Transmittance for Each Peak in the Watermelon Rind

Wavelength	3317.30	2094.80	1640.00	1088.40	607.60	432.40
Transmittance	48.65	96.59	68.06	48.550	41.98	57.33

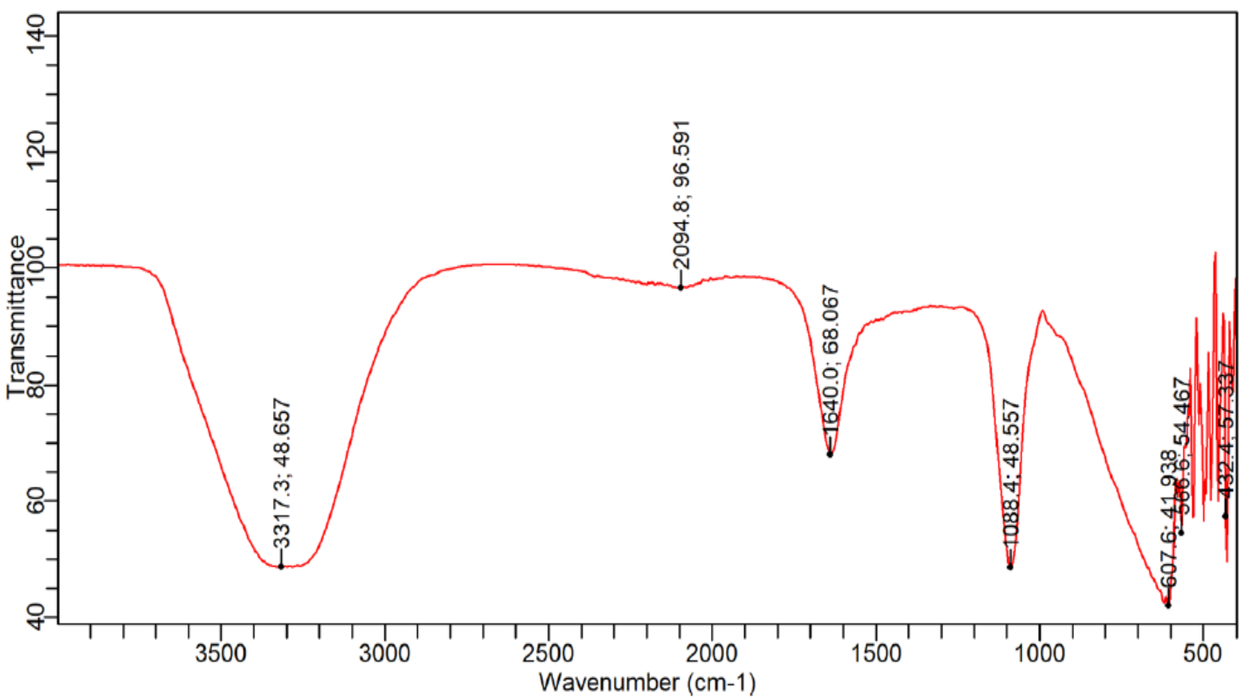

Figure 1: The FTIR Spectrum for the watermelon rind extract

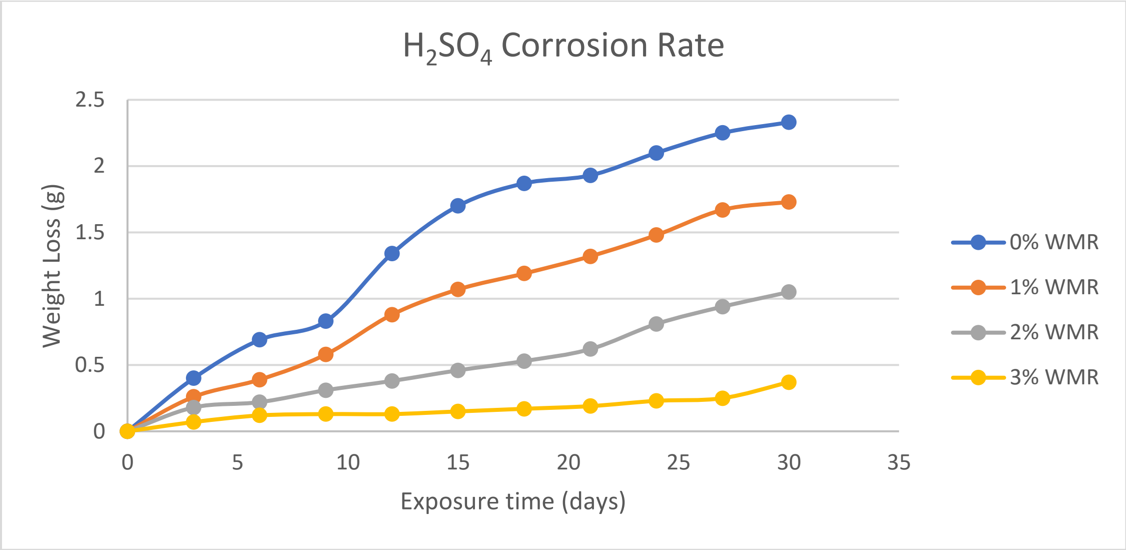

Figure 2: Weight loss variation with exposure time for API 5L steel immersed in 0.5 M H_2SO_4 with various concentrations of watermelon rind extract

Table 5: Corrosion parameters from the weight loss measurements of API 5L steel in 0.5 M H_2SO_4

Concentration (%)	Immersion Time (hours)	Weight loss (g)	Inhibition Efficiency (%)	Corrosion Rate (mmpy)
0	720	2.337	-	8.232E-03
1	720	1.735	25.75	6.112E-03
2	720	1.056	54.81	3.720E-03
3	720	0.374	84.00	1.317E-03

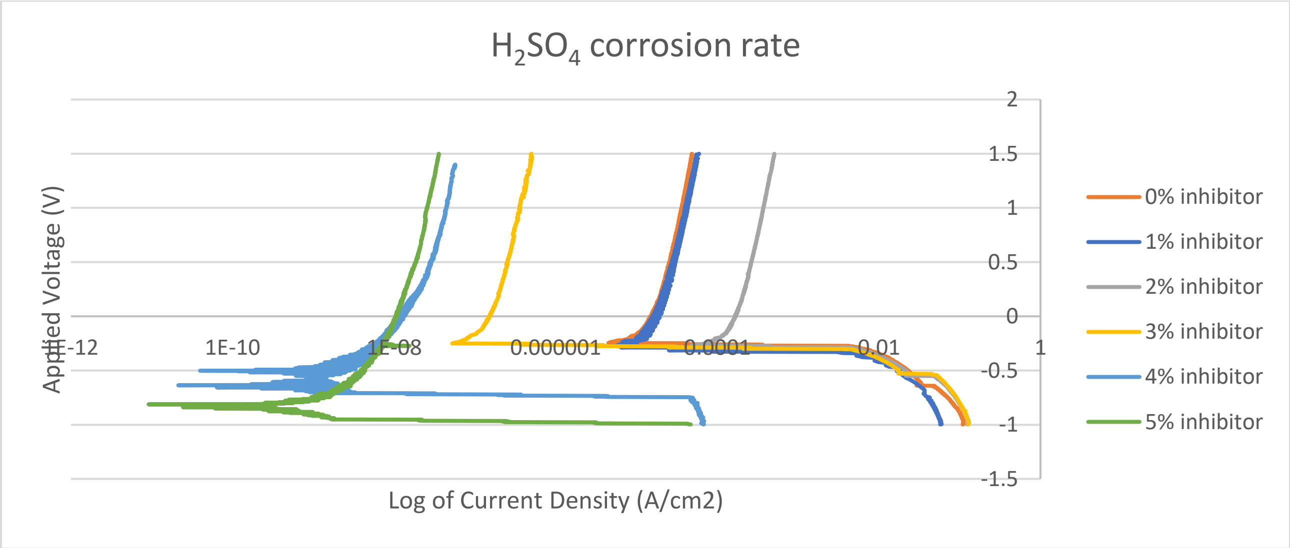

Figure 3: Polarization curves showing the corrosion behavior of API 5L Steel in 0.5M H_2SO_4 with various percentages of watermelon rind extract

Table 6: Polarization Values of API 5L Steel in 0.5M H_2SO_4 with Various Concentrations of WMR

	ba (V/dec)	**bc (V/dec)**	**E_{corr}(V)**	**I_{corr}(A/cm^2)**	**Corrosion Rate (mm/yr)**	**Polarization Resistance (Ω)**	**E begin (V)**	**Inhibitor Efficiency (%)**
0% WMR	1.09150	0.013904	-0.24363	9.2269E-06	1.0722E-01	646.19	-0.26764	-
1% WMR	0.03899	0.210600	-0.36053	2.2563E-06	2.6218E-02	6333.1	-0.31403	75.5%
2% WMR	0.11888	0.22959	-0.46553	5.2085E-07	6.0522E-03	65307	-0.24811	94.4%
3% WMR	0.02019	0.39853	-0.23916	6.4402E-08	7.4835E-04	1.2963E+05	-0.26520	99.3%
4% WMR	0.45126	0.12719	-0.65728	7.8745E-10	9.1501E-06	5.4724E+07	-0.67280	99.9%
5% WMR	0.04268	0.069563	-0.33987	1.7215E-10	2.0040E-06	6.6729E+07	-0.37018	99.9%

4.0 Conclusion

From the results obtained, it can be concluded that:

1. The presence of various phytochemicals in the watermelon rind is responsible for the good inhibitive properties possessed by the water melon rind.
2. The results from both the weight loss method and the polarization method showed the corrosion rate reduces with increase in the inhibitor concentration.
3. The highest inhibition efficiency value of 84% was obtained at 3% of the inhibitor concentration for the weight loss experiment.
4. The optimum inhibition efficiency value of 99.9% was attained at 4% inhibitor concentration for H_2SO_4.which was still retained at 5% for the polarization tests.

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