Inhibiting Effect of Banana Peel Extract (BPE) On the Corrosion of Aluminium and Mild Steel in a Sulphuric Acidic Environment

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Abstract- The aim of this research is to produce an efficient corrosion inhibitor from varying concentrations of the extract of Banana peel. The research was conducted in the Department of Mechanical Engineering, College of Engineering, Covenant University, Ota, Nigeria between January and September 2021. Mild steel and Aluminium metal samples were cut into equal rectangular dimensions of 1cm by 1.5cm each summing a total of 12 samples, 6 samples of aluminium and 6 samples of mild steel. These samples were each inserted in a sulphuric acid-water mixture (acid-environment) with varying concentrations of 0 (control), 2ml, 4ml, 6ml, 8ml and 10ml of the inhibitor. The samples were weighed for weight loss every 24 hours for a time duration of 21 days. The results showed that Banana peel extract is an effective corrosion inhibitor of mild steel and aluminium in H_2SO_4. The corrosion rate was observed to decrease with an increase in the concentration of the inhibitor. However little research has been done on aluminium using green/organic inhibitors, hence a gap which needs to be bridged. The result from the experiment showed that the inhibitor performed better in the inhibition of aluminium than on mild steel yielding an inhibition efficiency of 67.32%relative to mild steel of 62.40%. The result showed Banana Peel Extract (BPE) can be used as a corrosion inhibitor as this will curtail the relative use of inorganic inhibitors that are harmful and toxic to the environment. Using Banana peel extract was economically good as Banana is readily available and its extract is cheap to produce.

Indexed Terms- Organic Inhibitor, Mild Steel, Aluminium, Weight Loss

I. INTRODUCTION

Corrosion can cause serious damage to all sorts of things from dispensers, automobiles, dishwashers, bridges, buildings and steel used to make roads just like any other natural disaster would cause.

Corrosion is critical in many fields, including economics, resource management, and improved protection. Pipelines in the oil and gas industry, for example, are built to protect their integrity and make-up, but natural events such as corrosion cause leakages in the form of radioactive materials, implying a loss of natural resources and posing a hazard to the environment and human lives. With this, it is evident that the knowledge of corrosion and its control techniques cannot be overemphasized [1].

Corrosion is one of the major challenges that influence the performance, appearance and safety of materials. Corrosion has an impact on all areas of a country's economy, which is why it's crucial to develop materials that are affordable. It has been estimated that corrosion represents 4% of the gross national product and this figure represents the cost of corrosion control, losses for direct replacement of corroded materials and metals, and cost of replacement and new production.

Due to corrosion, the selection of materials for particular operations is difficult because some materials cannot function properly in certain environments and would corrode faster than other materials. To get these suitable corrosion-resistant materials, costs will have to increase. Over the years research has shown that the use of chemical inhibitors is the most practical and cost-effective means of controlling corrosion [2].

Different industries and sectors have depended on the utilisation of alloys and metals. A major challenge facing these industries is the protection of metals from corrosion. Corrosion has been a big issue to the metal industry and the world at large involving the destruction of metals by electrochemical or chemical reactions with the environment. This has really affected metal usage even in industries as there has been a dire need to find ways to combat corrosion. Corrosion prevention of metals is a very costly process and industries use large amounts to prevent this challenge. Corrosion destruction can be controlled by using different processes such as cathodic protection, barrier coatings, use of inhibitors. Among these processes, the use of corrosion of inhibitors is the best to control the degradation of surfaces of these materials. Different corrosion inhibitors have been put to the test, i.e organic and inorganic inhibitors and for different media, there have been good inhibiting efficiencies and showed a reduction in corrosion rate. Inorganic Inhibitors have helped over the years but due to high toxicity and corrosiveness, it has caused environmental degradation and depletion of the ozone layer. Therefore the need to get corrosion inhibitors that are environmentally friendly and non-toxic has increased as the world is going green. Natural inhibitors such as plant extracts have been discovered to act as corrosion inhibitors with some particular media like H_2SO_4 on different forms of steel like stainless steel, mild steel or aluminium alloys as these metals are readily available, light and used widely in the industry[3][4][5][6].

The most commonly used natural resource is metal. Metals are used by industries, organisations, businesses, societies, and individuals all over the world in the construction of infrastructure and the materials that are used to develop it. Corrosion is thus a challenge that must be solved in order to obtain the highest possible benefit through the use of metals.

Corrosion research has received much attention over the years, and the following are a few of the papers that address aspects of corrosion that are important to my research.

Manikandan et al.[7]studied the inhibition effect of banana peel extract (BPE) on the corrosion of mild steel in 0.1M HCl. The study was done by employing weight loss method and electrochemical techniques. The samples of the mild steel were also analyzed using FTIR spectroscopic technique. The results showed that the corrosion rate was slowed down as concentration of the inhibitor increased and in turn improved the inhibition efficiency of the mild steel. Results of the study indicated it had an optimum efficiency of 87%which was found to be successful.
Rosli et al.[8] studied the inhibitive effect of banana peel extract (BPE) on the corrosion of mild steel in 1M HCl. The study was investigated by the weight loss method. The results showed that inhibition efficiency of the extract increased from 86.9% to 89% as the concentration of the extract increased from 300ppm to 500ppm.

Eyu et al.[9] carried out research on the inhibitive performance of sodium nitrite on mild steel in a bicarbonate-chloride solution. The study was investigated using electrochemical techniques like potentio-dynamic polarisation. The structure of the surface of the metal was analysed using Scanning Electron Microscopy (SEM) and X-ray diffractometry (XRD). Results from this research showed sodium nitrite as an anodic inhibitor, and its efficiency was increased by the application of Iodide, I^-.Inhibition efficiency was optimum when sodium nitrite was equal to unity and worked effectively when synergised with potassium iodide

Tambun et al.[10]studied the inhibitive efficiency of banana peel on the corrosion of iron in 0.3M NaCl medium. The banana peel was varied in terms of the powder form it, its extract as well as the tannin from it. From the results obtained, it was discovered that all three products of the banana peel i.e tannin of the banana peel, the extract of the banana peel and the powder of the banana peel served as adequate corrosion inhibitors. FTIR Spectroscopic technique was used to analyse the sample of iron and it was seen that the highest and the lowest corrosion rate was obtained by using tannin of the banana peel as the corrosion inhibitor.

Chaubey et al.[10]investigated in their paper on the inhibition performance of three peels Pisum sativum (PS), Citrus reticulata (CR) and Solanum tuberosum (ST) on aluminium alloy in an alkaline medium, 1M

NaOH medium. The study was carried out using linear polarization, electrochemical impedance spectroscopy (EIS), potentio-dynamic polarization and weight loss method techniques. From the results it was found that these peel extracts showed good inhibitive performance on aluminium with Pisum Sativum exhibiting the highest efficiency at 94.5%. Adsorption was found to be the inhibitive mechanism it passed through obeying Langmuir's adsorption isotherm. The samples of aluminium were also studied using scanning electron microscope (SEM) and atomic force microscope (AFM).

As can be seen from the literature review above, different approaches are being followed in order to combat metal corrosion. Using eco-friendly or organic materials to avoid harm to the environment without losing the efficacy of inorganic inhibitors is one of these approaches.. The aim of this project is to compare the efficiency of banana peel extract (BPE) on aluminium and mild steel in the dilute acidic medium, H_2SO_4.

II. MATERIALS AND METHODOLOGY

The mild steel and aluminium samples used for this study were supplied by the metal and fabrication unit of the Mechanical Engineering Department, Covenant University, Ota, Ogun State, Nigeria and their chemical composition was obtained as shown in the tables below:

The composition of mild steel is shown in the table below, it shows the element and content in percentage, mild steel element includes carbon, silicon, manganese, phosphorus, sulphur, nickel, molybdenum, chromium, tungsten, copper and iron which forms mild steel.

Table I: Chemical Composition of Mild Steel

Element	%Content
C	0.090
Si	0.044
Mn	0.486
P	0.012
NI	0.052
MO	0.017
Cr	0.042
Cu	0.149
S	0.021
W	0.007
Fe	99.04

Composition of aluminium is shown on the table below, it shows the element and content in percentage, Aluminium element includes fluorine, aluminium, zinc, silicon, manganese, magnesium, lead, copper, tin, and silicon, which composes or forms the aluminium metallic sample.

Table II: Chemical Composition of Aluminium

Element	%Content
F	0.037
Si	0.084
Mn	<0.008
Cu	0.093
Zn	0.024
Ti	0.007
Mg	<0.008
Pb	0.012
Sn	0.007
Al	99.36

Alloy: NI -<0.008, Cr -< 0.008, V- < 0.008
Remarks: Be - <0.000, Sr – <0.000, Zr-0.008, Ca - < 0.001
Source: (Aluminium rolling mills, Ota, Ogun State)

Mild steel and Aluminium metal samples were cut into equal rectangular dimensions of 1cm by 1.5cm each summing a total of 12 samples, 6 samples of aluminium and 6 samples of mild steel. The experiment was performed using sulphuric acidic environment, consisting of 6 bottles each for both metals filled with 200ml amount of the acid-water mixture giving a sum total of 12 bottles. The Inhibitor concentration was specifically added to the acidic environments with varying concentrations of 0 (control), 2ml, 4ml, 6ml, 8ml and 10ml for the inhibitor.

2.1 Preparation of Banana Peel Extract:
The banana peel was air-dried for two weeks then crushed and stored in a clean container at room temperature for further analysis. The pulverized banana was extracted by maceration with methanol by soaking in 5L TLC tanks left covered for a period of 72 hours. Following that, cotton plugs and filter paper were used to filter the mixture. The extracts that resulted were then concentrated in vacuo at 45˚C using a rotary evaporator and stored in air-tight bottles prior to corrosion studies.

2.2 Weight Loss Method:
Abraded samples of mild steel and aluminium were subjected to three different emery sheets in order to determine how much galvanic action exists in the materials and whether it has an impact on the results. For the gravimetric testing, the samples were cleaned, degreased, and dried before being used for the testing. Once they had been weighed, the samples were submerged in cut bottles containing different volumes of H_2SO_4: 190ml, 192ml, 194ml, 196ml, 198ml, and 200ml, respectively. Measurements of 10ml, 8ml, 6ml, 4ml and 2ml respectively of the inhibitor were added to the solution of H_2SO_4. This analysis was carried out for a time duration of 504 hours (21 days). When this procedure was followed, every 24 hours, the samples were picked up, dipped in water and acetone, dried, and weighed appropriately. A discrepancy exists between the weight of the sample before and after the test.

Weight loss is calculated by W= initial weight – final weight.

The Corrosion Rate for the experiment was calculated from the weight loss
Corrosion Rate = (87.6 * W/DAT) mm/yr
Where;
W= weight loss in grams
D = density of metal (g/cm^3)
A = surface area of metal (cm^2)
T = exposure time (hrs)

The inhibition efficiency is also calculated from the weight loss experiment
I.E = {(W1-W2)/W1} * 100
Where;
W1 = the weight loss of the control sample
W2 = the weight loss of other metallic samples
Surface coverage is calculated as;
Surface coverage = (1-W2/W1)
OR surface coverage = I.E/100.

III. RESULTS AND DISCUSSION

- Aluminium

Table III: Results of H_2SO_4 Banana Peel Extract

SAMPLE	WEIGHT LOSS (G)	CORROSION RATE	INHIBITION CONCENTRATION (MM/Y)	INHIBITION EFFICIENCY (%)	SURFACE COVERAGE
A	0.0814	0.0052	0	0	0
B	0.0634	0.0041	1	22.11	0.2211
C	0.0626	0.0040	2	23.09	0.2309
D	0.0450	0.0028	3	44.71	0.4471
E	0.0445	0.0028	4	45.33	0.4533
F	0.0266	0.0017	5	67.32	0.6732

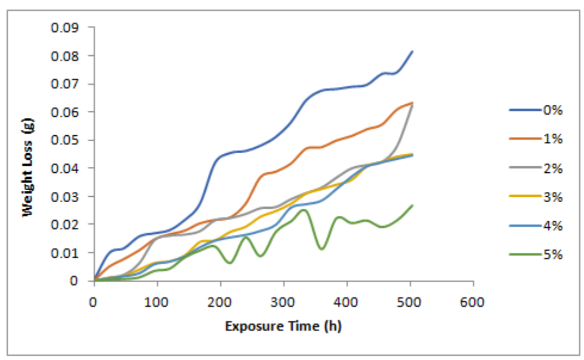

Figure 1: Weight Loss of Aluminium in H_2SO_4 Banana Peel Extract

The weight loss result of the corrosion inhibition of aluminium in Banana Peel Extract is shown in Table III. The graph of the weight loss of aluminium is plotted against the exposure of time with a 24 hour interval which is shown above in figure 1. From the table III, at 1% the inhibitor concentration is 2ml, at

2% is 4ml, at 3% is 6ml, at 4% is 8ml and at 5% is 10ml, from the graph it is seen that at 0% (which is without the addition of inhibitor) increased notably with respect to the exposure time as compared to other samples of various inhibitor concentration attaining a weight loss value of 0.0814g at 504 hours. This is due to the presence of sulphate ions (SO_4^{2-}) from the sulphuric acid which speeds up the rate of corrosion on the sample. At 4% and 5% the weight loss values are 0.0445g and 0.0266g respectively at 504 hours which from the graph are seen with the sample with the least weight loss value. At 1%, 2% and 3% the weight loss value are 0.0634g, 0.0626g and 0.0450g respectively from the graph at 504 hours has higher values. From the experiment and the graph, it can be concluded that 5% with weight loss of 0.0266g is most effective in corrosion control having a weight loss value as compared with the control value and other varied concentrations of the inhibitor.

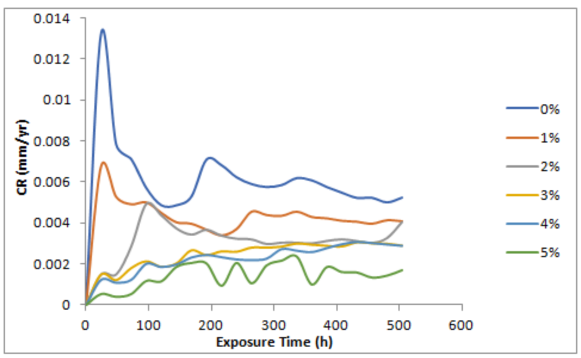

Figure 2: Corrosion Rate of Aluminium in H_2SO_4 Banana Peel Extract

The rate of corrosion of aluminium samples in the solution over the given period was calculated using the weight loss of each samples, the density and surface area of the aluminium. The data gotten from the calculated corrosion rate of Aluminium samples is shown in the table above with the graph of the corrosion rate against the exposure time also shown above in figure 2. At 0% the control sample had a corrosion value of 0.0052 having the highest corrosion rate value due to absence of inhibitor and the effect of acid environment on the sample while on the other hand 5% the 10g sample had a corrosion rate of 0.0017 which is the lowest corrosion rate value due to the presence of inhibitor.

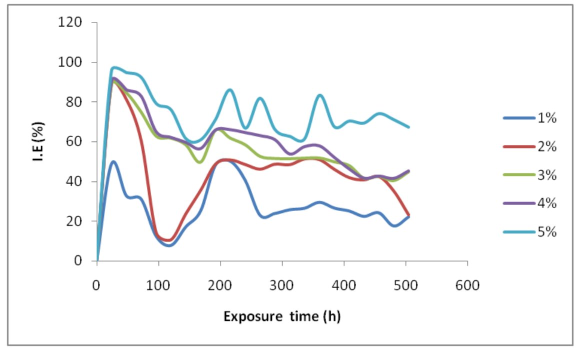

Figure 3: I.E (%) of Aluminium in H_2SO_4 Banana Peel Extract

The inhibitor efficiency value were calculated from the weight loss values and the data above was obtained, the inhibitor efficiency is shown in the table in Table III above and the graph of inhibitor efficiency against exposure time which is seen in figure 3. At 5% the inhibitor efficiency with respect to exposure time is significantly higher than the other aluminium samples having an inhibitor efficiency value of 67.32 and a surface coverage value of 0.6732 at 504 hours. And at 1%, 2%, 3%, and 4% the inhibitor efficiency values are 22.11, 23.09, 44.71 and 45.33 respectively with a surface coverage value of 0.2211, 0.2309, 0.4471 and 0.4533 respectively. Sample with 2ml had the lowest inhibitor efficiency at 504 hours. From the experiment sample with 10ml had better inhibition efficiency and a better surface coverage value than the other samples thereby reducing the corrosion rate of the sample.

- Mild Steel

Table IV: Results of H_2SO_4 Banana Peel Extract

SAMPLE	WEIGHT LOSS (G)	CORROSION RATE	INHIBITION CONCENTRATION (MM/Y)	INHIBITION EFFICIENCY (%)	SURFACE COVERAGE
A	0.2125	0.0047	0	0	0
B	0.2018	0.0044	1	5.03	0.0503
C	0.1650	0.0036	2	22.35	0.2235
D	0.13	0.0028	3	38.63	0.386

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E	0.0848	0.0018	4	60.09	0.6009
F	0.0799	0.0017	5	62.4	0.6224

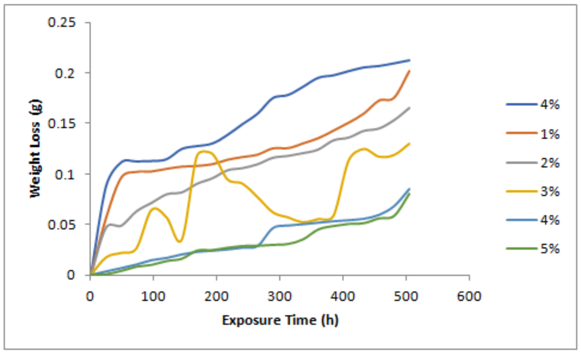

Figure 4: Weight Loss of Mild Steel in H_2SO_4 Banana Peel Extract

The weight loss result of the corrosion inhibition of mild steel in Banana Peel Extract is shown in Table 4. The graph of the weight loss of aluminium is plotted against the exposure of time with a 24 hour interval which is shown above in figure 4. From the table IV, at 1% the inhibitor concentration is 2ml, at 2% is 4ml, at 3% is 6ml, at 4% is 8ml and at 5% is 10ml, from the graph it is seen that at 0% (which is without the addition of inhibitor) increased notably with respect to the exposure time as compared to other samples of various inhibitor concentration attaining a weight loss value of 0.2125 at 504 hours. This is due to the presence of sulphate ions (SO_4^{2-}) from the sulphuric acid which speeds up the rate of corrosion on the sample. At 4% and 5% the weight loss values are 0.0848g and 0.0799g respectively at 504 hours which from the graph are seen with the sample with the least weight loss value. At 1%, 2% and 3% the weight loss value are 0.2018g, 0.165g and 0.1304g respectively from the graph at 504 hours has higher values. From the experiment and the graph it can be concluded that at 5% with weight loss of 0.0799g is most effective in corrosion control having a weight loss value as compared with the control value and other varied concentrations of the inhibitor

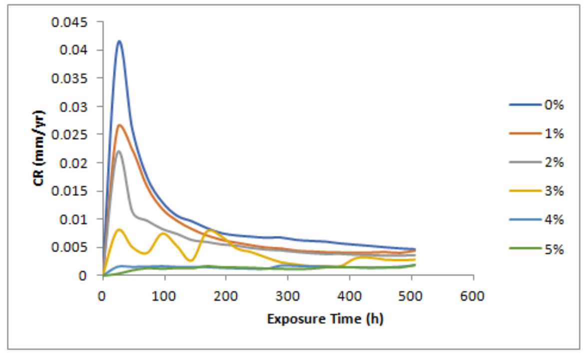

Figure 5: Corrosion Rate of Mild Steel in H_2SO_4 Banana Peel Extract

The rate of corrosion of mild steel samples in the solution over a given period of time was calculated using the weight loss of each samples, the density and surface area of the aluminium. The data gotten from the calculated corrosion rate of Aluminium samples is shown on the table above with the graph of the corrosion rate against the exposure time is also shown above in figure 5. At 0% the control sample had a corrosion value of 0.00471 having the highest corrosion rate value due to absence of inhibitor and the effect of acid environment on the sample while on the other hand 5% the 10g sample having a corrosion rate of 0.00177 which is the lowest corrosion rate value due to the presence of inhibitor

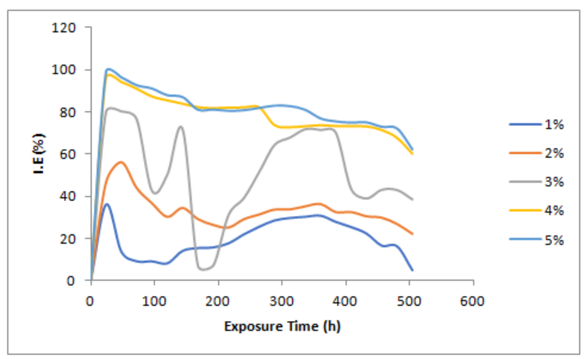

Figure 6: I.E (%) of Mild Steel in H_2SO_4 Banana Peel Extract

The inhibitor efficiency value were calculated from the weight loss values and the data above was obtained, the inhibitor efficiency is shown in the table in Table IV above and the graph of inhibitor efficiency against exposure time which is seen in figure 6.At 5% the inhibitor efficiency with respect to exposure time is significantly higher than the other aluminium samples having an inhibitor efficiency value of 62.40 and a surface coverage value of 0.6240 at 504 hours. And at 1%, 2%, 3%, and 4% the inhibitor efficiency values are 5.04, 22.35, 38.64 and 60.09 respectively with a surface coverage value of 0.0504, 0.2235, 0.3864 and 0.6009 respectively. Sample with 2ml had the lowest inhibitor efficiency at 504 hours. From the experiment sample with 10ml had better inhibition efficiency and a better surface coverage value than the other samples thereby reducing the corrosion rate of the sample.

CONCLUSION

The use of Banana peel extract gave a notably good result on the corrosion inhibition of mild steel and aluminium in a Sulphuric acid environment. From the experiment, we would discover that the inhibitor is more efficient on aluminium giving an inhibitor efficiency of 67.32% while on mild steel giving an inhibitor efficiency of 62.40%. In conclusion, the organic inhibitor was a better corrosion inhibitor on aluminium than on mild steel in the acidic environment. This research comes timely as the world goes green and all efforts are on deck to reduce toxic substances penetrating the atmosphere. However little research has been done on aluminium using green/organic inhibitors, hence a gap which needs to be bridged.

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