A Model to Predict the Inhibitive Property of PKO on Crude Oil Pipeline.

O.K. Ukoba, B.Eng.[1]; U.S. Anamu, B.Eng.[*1]; O. Ogundare, M.Eng.[1]; M.C. Ibegbulam, B.Eng.[1]; and O.A. Akintunlaji, M.Eng.[2]

[1] Engineering Materials Development Institute, Akure, Ondo State, Nigeria.
[2] University of Agriculture, Abeokuta, Ogun State, Nigeria.

E-mail: usanamu2009@yahoo.com*

ABSTRACT

The incessant pipeline bursts in the Niger Delta part of Nigeria have become a source of concern to all stakeholders resulting from the loss of resources and lives in the area. Corrosion of the pipeline was identified as a major player in this problem. This research aimed to investigate the inhibitive property of Palm Kernel Oil (PKO), an inorganic inhibitor, on crude oil pipeline and come up with a model (non-linear regression analysis) to forecast and predict it. The result was of great interest as it reveals some interesting results. The equation is Corrosion Rate = 5.927 - (0.0164 * days).

(Keywords: inhibitor, palm kernel oil, PKO, crude oil, corrosion, model, pipeline)

INTRODUCTION

Despite the developments in corrosion resistant alloys over the past few decades, carbon steel still constitutes an estimated 99% of the material used in the oil industry. It is usually the most cost effective option, being a factor of 3 to 5 times cheaper than stainless steels. Yet its corrosion resistance is poor in aggressive environments, and the cost savings can only be realized by adding a corrosion inhibitor to the environment or applying a protective coating to the steel. Inhibitors are used in a wide range of applications, such as oil pipelines, domestic central heating systems, industrial water cooling systems and metal extraction plants.

A particular advantage of corrosion inhibition is that it can be implemented or changed *in situ* without disrupting a process. The major industries using corrosion inhibitors are the oil and gas exploration and production industry, the petroleum refining industry, the chemical industry, heavy industrial manufacturing industry, water treatment facilities, and the product additive industries. The largest consumption of corrosion inhibitors is in the oil industry, particularly in the petroleum refining industry. [1]

Oil spills are a common event in Nigeria [2] and occur due to a number of causes, including: corrosion of pipelines and tankers (accounting for 50% of all spills), sabotage (28%), and oil production operations (21%), with 1% of the spills being accounted for by inadequate or non-functional production equipment. The largest contributor to the oil spill total, corrosion of pipes and tanks, is the rupturing or leaking of production infrastructures that are described as, "very old and lack regular inspection and maintenance".[3]

A reason that corrosion accounts for such a high percentage of all spills is that as a result of the small size of the oilfields in the Niger Delta, there is an extensive network of pipelines between the fields, as well as numerous small networks of flowlines, the narrow diameter pipes that carry oil from wellheads to flowstations allowing many opportunities for leaks. In onshore areas, most pipelines and flowlines are laid above ground. Pipelines, which have an estimate life span of about fifteen years, are old and susceptible to corrosion. Many of the pipelines are as old as twenty to twenty-five years. [4] Even Shell admits that "most of the facilities were constructed between the 1960s and early 1980s to the then prevailing standards. SPDC [Shell Petroleum and Development Company] would not build them that way today."[5] Sabotage is performed primarily through what is known as "bunkering", whereby the saboteur attempts to tap the pipeline. In the process of extraction sometimes the pipeline is damaged or destroyed. Oil extracted in this manner can often be sold.

Damaged lines may go unnoticed for days, and repair of the damaged pipes takes even longer. [6] Nigerian regulations of the oil industry are weak and rarely enforced allowing, in essence, the industry to self-regulate. [2]

It is noteworthy that, the devastating consequences of the spill of this crude in the Niger Delta region with its eventual hazards on both aerial and terrestrial environs tantamount to an irreversible chain effect on both the bio-diversity and human safety. [8] Against this background this study was undertaken to predict the inhibitive property of PKO on crude oil pipeline to possibly curb the menace of corrosion.

MATERIALS AND METHODS

Methodology

The following materials were used during the experiment:

2mm by 2mm mild steel was dipped into150ml crude oil (control set up) and later into a mixture of 150ml Crude Oil and 5ml of Palm Kernel Oil (popularly referred to as black cream in Nigeria).

Every two weeks for 70 days the samples were removed and measured to determine the rate of inhibition of corrosion on the steel pipeline.

Materials

Other materials used are:

i. Syringe used in "injecting" the PKO
ii. Measuring flask to measure the Crude Oil and the PKO
iii. Weight balance to measure the weight of the sample

RESULT AND DISCUSSION

Corrosion Rate (gcm-^{2}hr^{-1}) = $\frac{weight}{Area\ x\ Time}$

Table of Values

Table1: Control Set-up of the Weight Loss of Mild Steel with Time (period) in Crude Oil Environment.

Period (days)	Initial Mass (g)	Final Mass (g)	Weight Loss (g)
1	5.990	5.990	0
14	5.990	5.698	0.292
28	5.990	4.865	1.125
42	5.990	4.654	1.339
56	5.990	3.772	2.218
70	5.990	3.185	2.805

Table 2: Control Set-up of the Weight Loss of Mild Steel with Weight Loss Percentage in Crude Oil Environment.

Period (days)	Initial Mass (g)	Final Mass (g)	Weigh t Loss (g)	Weight loss % (%)
1	5.990	5.990	0	0
14	5.990	5.698	0.292	4.875
28	5.990	4.865	1.125	18.781
42	5.990	4.652	1.339	22.346
56	5.990	3.772	2.218	37.035
70	5.990	3.185	2.805	46.828

Figure 3: Control Set-up of Weight Loss of Mild Steel with Corrosion Rate in Crude Oil Environment.

Period (days)	Initial Mass (g)	Final Mass (g)	Weight Loss (g)	Corrosion rate (g/cm^{2}day)
1	5.990	5.990	0	149.75
14	5.990	5.698	0.292	10.696
28	5.990	4.865	1.125	5.348
42	5.990	4.652	1.339	3.565
56	5.990	3.772	2.218	2.674
70	5.990	3.185	2.805	2.139

Table 4: Weight Loss of Mild Steel with Time in Crude Oil Environment using PKO as Inhibitor.

Period (days)	Initial Mass (g)	Final Mass (g)	Weight Loss (g)
1	5.990	5.990	0
14	5.990	5.772	0.218
28	5.990	5.300	0.69
42	5.990	5.146	0.844
56	5.990	5.015	0.975
70	5.990	4.883	1.107

Table 5: Weight Loss of Mild Steel with Weight Loss Percentage in Crude Oil Environment using PKO as inhibitor.

Period (days)	Initial Mass (g)	Final Mass (g)	Weight Loss (g)	Weight loss % (%)
1	5.990	5.990	0	0
14	5.990	5.772	0.218	3.639
28	5.990	5.300	0.69	11.519
42	5.990	5.146	0.844	14.090
56	5.990	5.015	0.975	16.277
70	5.990	4.883	1.107	18.481

Table 6: Weight Loss of Mild Steel with Corrosion Rate in Crude Oil Environment using PKO as Inhibitor.

Period (days)	Initial Mass (g)	Final Mass (g)	Weight Loss (g)	Corrosion rate (g/cm^{2}day)
1	5.990	5.990	0	149.75
14	5.990	5.772	0.218	10.696
28	5.990	5.300	0.69	5.348
42	5.990	5.146	0.844	3.565
56	5.990	5.015	0.975	2.674
70	5.990	4.883	1.107	2.139

GRAPHS

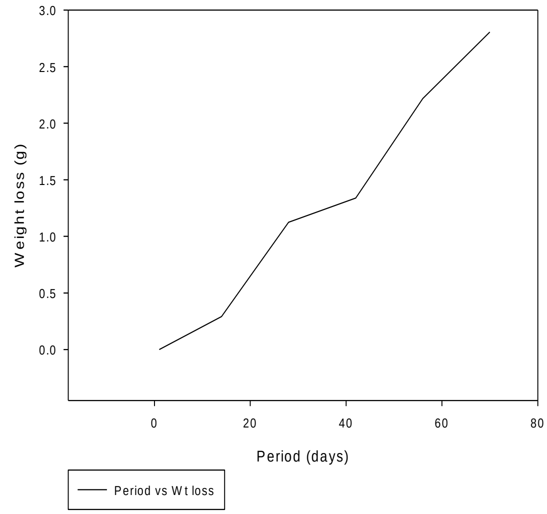

Figure 1: Graph of Weight Loss against Period in Crude Oil Environment Uninhibited.

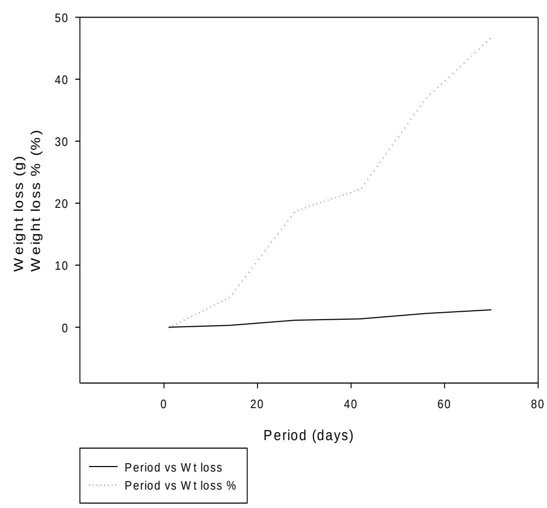

Figure 2: Graph of Weight Loss and Weight Loss Percentage against Period in Crude Oil Environment Uninhibited.

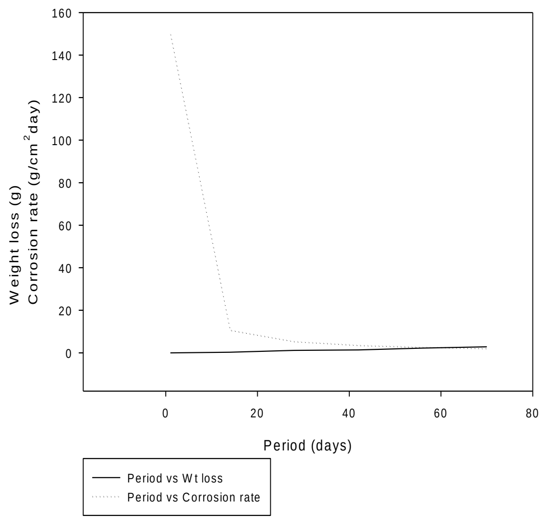

Figure 3: Graph of Weight Loss and Corrosion Rate against Period in Crude Oil Environment Uninhibited.

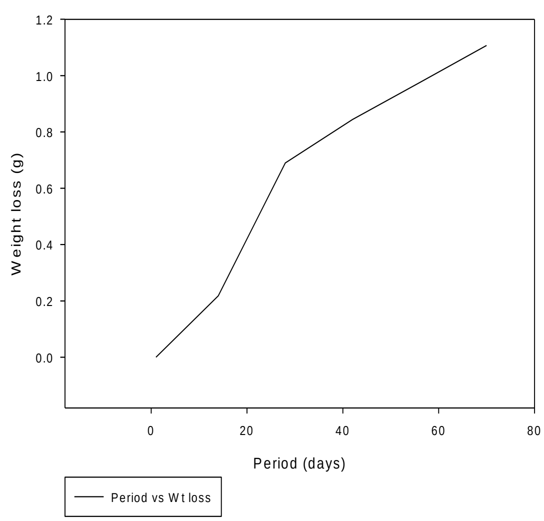

Figure 4: Graph of Weight Loss against Period in Crude Oil Environment Inhibited.

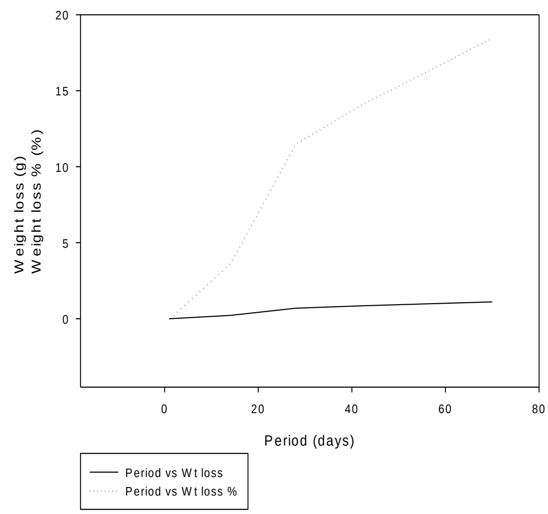

Figure 5: Graph of Weight Loss and Weight Loss Percentage against Period in Crude Oil Environment Inhibited.

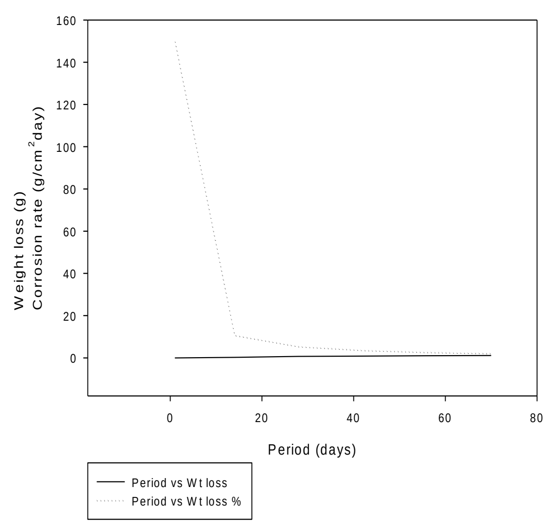

Figure 6: Graph of Weight Loss and Corrosion Rate against Period in Crude Oil Environment Inhibited.

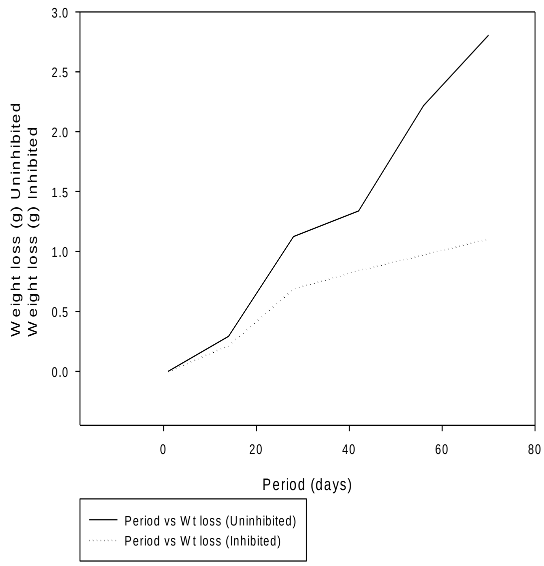

Figure 7: Graph of Weight Loss Uninhibited and Weight Loss Inhibited against Period in Crude Oil Environment.

Mathematical Model

Data Source: Data 1 in Notebook 1

Corrosion rate = 5.927 - (0.0164 * days)

N = 6 Missing Observations = 1

R = 0.969 Rsqr = 0.938 Adj Rsqr = 0.923

Standard Error of Estimate = 0.122

	Coefficient	**Std. Error**	**t**	**P**
Constant	5.927	0.0891	66.533	<0.001
Period (days)	-0.0164	0.00210	-7.798	0.001

Analysis of Variance:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.903	0.903	60.810	0.001
Residual	4	0.0594	0.0148		
Total	5	0.962	0.192		

Normality Test (Shapiro-Wilk) Passed (P = 0.277)

Constant Variance Test: Passed (P = 0.060)

Power of performed test with alpha = 0.050: 0.948

DISCUSSION

A close look at the result of Tables 1-3 for the uninhibited (control set up) environment revealed a trend of increase in weight loss of the mild steel with respect to period of time in days.

A similar trend was observed in Tables 4-6 with the inhibitor introduced.

Comparatively, it was observed that the weight loss for the uninhibited environment under the same condition of time is higher than in the inhibited environment.

The graphs of the figures better illustrate the results explained above.

The Mathematical Model: From the Linear regression test performed, the Normality Test (Shapiro-Wilk) gave a Passed at (P = 0.277) while the Constant Variance Test: Passed at (P = 0.060). Also, the Power of performed test with alpha = 0.050: 0.948 and the analysis of variance for the regression gave a P value of 0.001.

Effect of Inhibitor Concentration

The use of Palm Kernel Oil as an inhibitor for the corrosion of mild steel in crude oil pipeline has been clearly demonstrated in Figures 4–6. The corrosion rate curves of the mild steel in crude oil with PKO at different time decreases with increasing period of time in days. Owing to the fact that it is oil based, no doubt it is considered as one of the most effective corrosion inhibitor and coating that corroborates the works of several other researchers who recently developed interests in the use of PKO as effective inhibitor.

CONCLUSION

In conclusion, the corrosion rate for crude oil Pipeline using Palm Kernel Oil (black cream) as inhibitor can be predicted using this equation **Corrosion rate = 5.927 - (0.0164 * days).**

REFERENCES

1. “Issues in the Niger Delta”. Retrieved June, 2011 from http://en.wikipedia.org/wiki/environmental

2. Baird, J. 2010. "Oil's Shame in Africa". *Newsweek*. 27.

3. Nwilo, P.C. and Badejo, O.T. 2001. "Impacts of Oil Spills Along the Nigerian Coast". *The Association for Environmental Health and Sciences.*

4. Manby, B. 1999. "The Price of Oil". *Human Rights Watch*. Retrieved November 9, 2007.

5. Shell International Petroleum Company. 1995. *Developments in Nigeria*. SIPC: London, UK.

6. Anderson, I. 2005. "A Vision for Sustainable Development". *Niger River Basin*. 1-131.

7. CNN. 2006. "Pipeline Explosion Kills at Least 200". Retrieved May 29, 2007.

8. Pourbaix, M. 1974. *Atlas of Electrochemical Equilibria in Aqueous Solution*. NACE: Huston, TX.

9. SigmaPlot 11.0 and Microsoft Excel.

ABOUT THE AUTHORS

U.S. Anamu, holds a B.Eng. degree in Metallurgical and Materials Engineering from the Federal University of Technology, Akure. He is currently working as a Method Engineer in the Department of Foundry at the Engineering Materials Development Institute (EMDI), Akure. His research interests are in the areas of structural materials and characterization, foundry technology, corrosion, ceramics and refractories.

C.M. Ibegbulam, is a bachelor degree holder in Materials and Metallurgical Engineering and his currently a research officer in Engineering Materials Development Institute, Akure, Ondo State (EMDI). His research interests are in the areas of Corrosion Science and Materials & Metallurgical Engineering.

O.K. Ukoba, is a Design and Simulation Engineer in the Manufacturing Department, Engineering Materials Development Institute, Akure, Nigeria. He holds a B.Eng. degree in Mechanical Engineering and currently doing his M.Eng. in Mechanical Engineering. His research interests are in the areas of Design/Simulation, Materials (Testing and synthesis), Corrosion and Ergonomics.

O.A. Akintunlaji, holds an M.Eng. degree in Mechanical Engineering. He is currently pursuing a Ph.D. degree in Mechanical Engineering at the University of Agriculture, Abeokuta, Nigeria. His research interests are in the areas of Computer-Aided Manufacturing.

O. Ogundare, holds a Master degree in Materials Engineering from the Obafemi Awolowo University, Ile Ife Nigeria and a Bachelor of Engineering degree in Metallurgical and Materials Engineering from the Federal University of Technology Akure, Nigeria. He is currently a doctoral degree student at the Department of Materials Science and Engineering, Obafemi Awolowo University Ile Ife Nigeria. His research interests are in electrochemistry, structure property relationships and materials testing. He is currently a Research and Development Officer with Engineering Materials Development Institute Akure Nigeria.

SUGGESTED CITATION

Ukoba, O.K., U.S. Anamu, O. Ogundare, M.C. Ibegbulam, and O.A. Akintunlaji. 2011. "A Model to Predict the Inhibitive Property of PKO on Crude Oil Pipeline". *Pacific Journal of Science and Technology*. 12(2):39-44.

Pacific Journal of Science and Technology