Inhibitive Effect of Bitter Kola Extract on Aluminium Corrosion in Hydrochloric Acid Medium

[1]A.O. James, [2]F.A. Odey

[1] Department of Pure and Industrial Chemistry,
University of Port Harcourt. P.M.B. 5323, Port Harcourt.
[1] Email address: bidean2002@yahoo.com
[1]Phone Number: +2347067986462

[2] Department of Pure and Industrial Chemistry,
University of Port Harcourt. P.M.B. 5323, Port Harcourt.
[2] Email address: fgcfaith2@yahoo.com
[b]Phone Number: +2348167028150

ABSTRACT: The inhibitive effect of different concentrations (10%v/v to 50%v/v) of bitter kola water-extract (BK) on the corrosion of aluminum in 0.5M hydrochloric acid was investigated by weight loss technique at 30oC to 50oC. The percentage inhibition efficiency increased with the concentration of the inhibitor and the temperatures. The mechanism of chemical adsorption has been proposed for the inhibitor on the basis of the temperature effect and the values of activation energy obtained. The inhibition is probably due to the adsorption of kola flavonone which is the active component in bitter kola extract on aluminum surface. The adsorption of the inhibitor molecule on aluminum surface was in accordance with Langmuir adsorption isotherm. The results from weight loss technique confirmed that bitter kola water - extract (BK) is effective in reducing the corrosion of aluminum in hydrochloric acid medium and could serve as an effective and non-toxic inhibitor of the corrosion of aluminum in hydrochloric acid solution at the temperatures studied.

Keywords: Corrosion, Surfaces, Structural, kola flavonone, Organic.

1. INTRODUCTION

Exposure of metals to aggressive environments such as the use of acid solutions for pickling, chemical and electrochemical etching of metal, industrial acid cleaning, cleaning of oil refinery equipment, oil well acidizing and acid descaling usually lead to loss of the metal due to corrosion [1]. It has been estimated that approximately 5% of an industrialized nations income is spent on corrosion prevention, maintenance and replacement of products lost or contaminated as a result of corrosion reactions. Therefore, corrosion poses one of the biggest problems to the economy of a nation [2].

***Correspounding Author: [a]James, A.O.**
[a]Email address: bidean2002 @yahoo.com
Tel: +2347067986462.

Corrosion not only has economic implications but also social and these include the safety and health of people either working in industries or living in nearby towns. The petroleum industry is one of the most affected by corrosion. This is because the presence of many corrosive substances in the crude oil, from the extraction of crude oil to the transportation of final products, affects equipment and pipelines [3].

The use of inhibitors is one of the best options of protecting metals against corrosion. Several inhibitors in use is either synthesized from cheap raw material or chosen from organic compounds having heteroatoms in their aromatic or long chain carbon system [4].

However, most of the inhibitors are toxic to the environment. In an attempt to find corrosion inhibitors which are environmentally safe and readily available, there has been a growing trend in the use of natural products such as leaves or plant extracts as corrosion inhibitors for metals in acid cleaning process [5].

Garcinia kola exhibits purgative, anti-parasitic, anti-inflammatory, anti-bacterial and antiviral properties [6]. A thorough review of the literature revealed that ethanol extract of garcinia kola has been used to inhibit the corrosion of mild steel [7] and aluminum [8] in sulphuric acid. Bitter kola has been analyzed and found to contain Kolaflavonone [9] which is the active component in bitter kola responsible for the adsorption of the inhibitor on the metal surfaces.

Presently to the best of our knowledge, there is no reported work on the use of bitter kola water-extract as inhibitor of aluminum in hydrochloric acid.

Therefore this paper reports the inhibitive effect of BK on corrosion of aluminium in 0.5M hydrochloric acid using weight loss method.

2. MATERIALS AND METHOD

The weight loss corrosion test method was used for this study.

2.1 Metal Preparation

The Aluminum test specimens of dimensions 4cm by 3cm were cut from aluminum sheet of 0.5mm in thickness and 98.76% purity. The aluminum coupons were prepared, cleaned and preserved to avoid contamination.

2.2 Weight Loss Method of Corrosion measurement

0.5M Hydrochloric acid was employed as the aggressive solution for this study. The stock solution of bitter kola was crushed and extracted in water. The stock solution of the bitter kola was diluted with appropriate quantity of 0.5M hydrochloric acid solution to obtain inhibitor test solutions of 10% to 50% (v/v) concentrations. The procedure for weight loss determination was as previously reported [10]. Previously weighed aluminum coupons in 100mL open beakers containing 50mL of 0.5M hydrochloric acid (blank) and then with addition of different bitter kola concentrations to the 0.5M hydrochloric acid (10 – 50%, v/v) at 30^{o}C to 50^{o}C. The weight losses of the coupons were monitored for 210 consecutive mins at 30mins interval for 30^{o}C to 50^{o}C as presented in fig 1 to fig 3. Duplicate experiments were conducted at the same time and the average values were taken. Corrosion rate (mm/year), percentage inhibition efficiency (n%) and the surface coverage (Θ) were calculated for 140 min immersion period using the following equations:

$$\text{Corrosion rate (mm/year)} = \frac{87.6w}{DAt} \quad \ldots\ldots\ldots\ldots (1)$$

$$\%\,\mathrm{E} = \frac{\Delta W_B - \Delta W_i}{\Delta W_B} \; x \; \frac{100}{1} \quad \ldots\ldots\ldots (2)$$

$$\theta = \frac{\%E}{100} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where w is the weight loss of aluminium (mg), D is the density of the aluminum (gcm^{-3}), A is the area of specimen (cm^{2}), and t is the immersion time (h).

3. RESULTS AND DISCUSSION

3.1 Inhibitory action of bitter kola extract on the corrosion of aluminium

The correlation of weight loss of aluminum coupons with time in hydrochloric acid and in the presence of different concentrations of bitter kola extract is shown in fig 1 to fig 3. This figures shows that the introduction of the bitter kola extract at different concentrations to the acid solution decreased the value of material loss from the surface of aluminum and the decreased deflection of weight loss rate with time for 10 – 50% (v/v) bitter kola concentrations. This observation in fig 1 to 3 shows that bitter kola acts as an inhibitor of aluminum corrosion in 0.5M hydrochloric acid at the studied concentrations. It is evident in Table 1 that the weight loss decreased with increasing concentrations of the bitter kola and temperatures in hydrochloric acid solutions and the inhibition efficiency increases with increasing bitter kola concentrations. The observation in fig 4 portrays an increase in inhibition efficiency of bitter kola extract as the concentration of extract increases in the acid solution. This can be observed from the upward progression of all three temperatures.

This behavior indicates that the inhibition is due to the adsorption of inhibitor's molecule onto the aluminum surface and bitter kola acts as an adsorption inhibitor.

Bitter kola is a good inhibitor of corrosion of aluminum in hydrochloric acid solution with 82.96% inhibition in 50%, (v/v) at 50^{o}C. The inhibitory effect of the bitter kola is ascribed to the presence of kola flavonone which is the active component in bitter kola

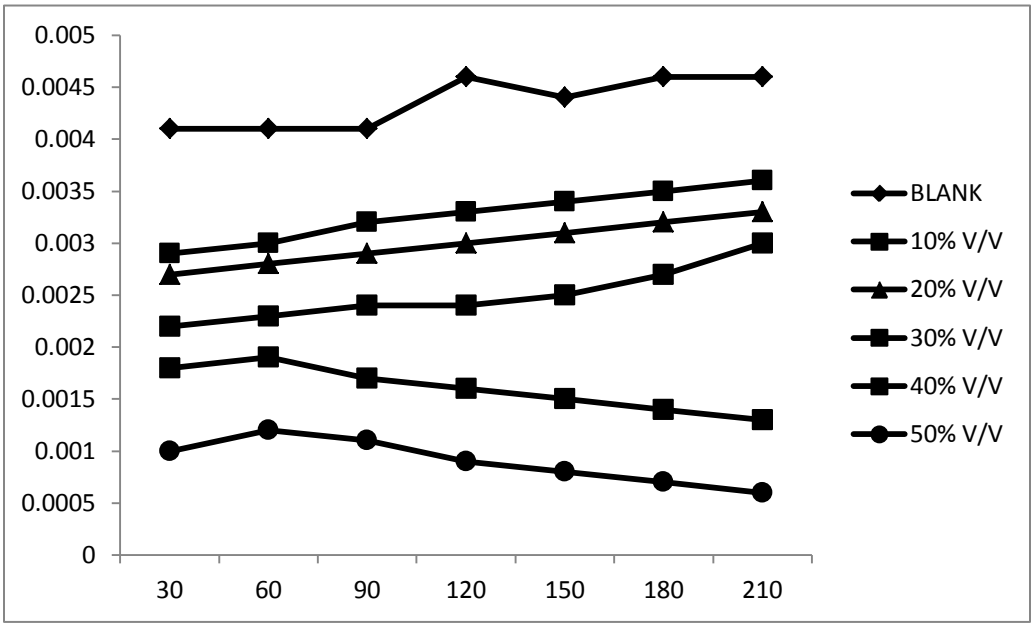


FIGURE 1: Variation of weight loss with time for aluminium coupons in 0.5M hydrochloric acid solution containing different concentrations of bitter kola extract at 30°C.

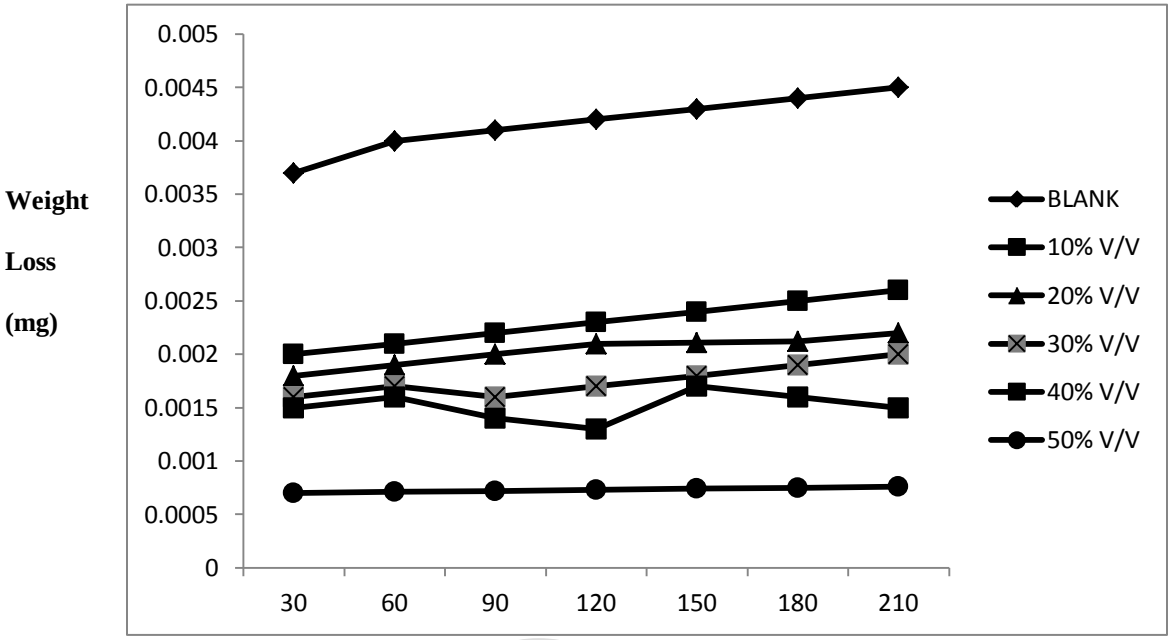


FIGURE 2: Variation of weight loss with time for aluminium coupons in 0.5M hydrochloric acid solution containing different concentrations of bitter kola extract at 40°C.

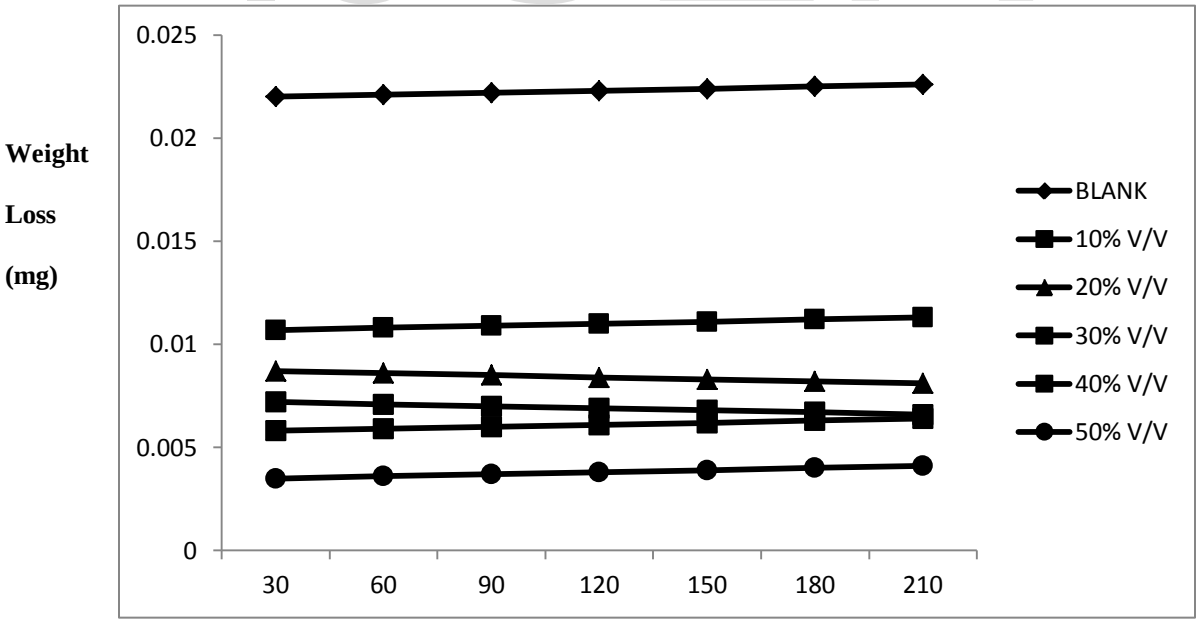
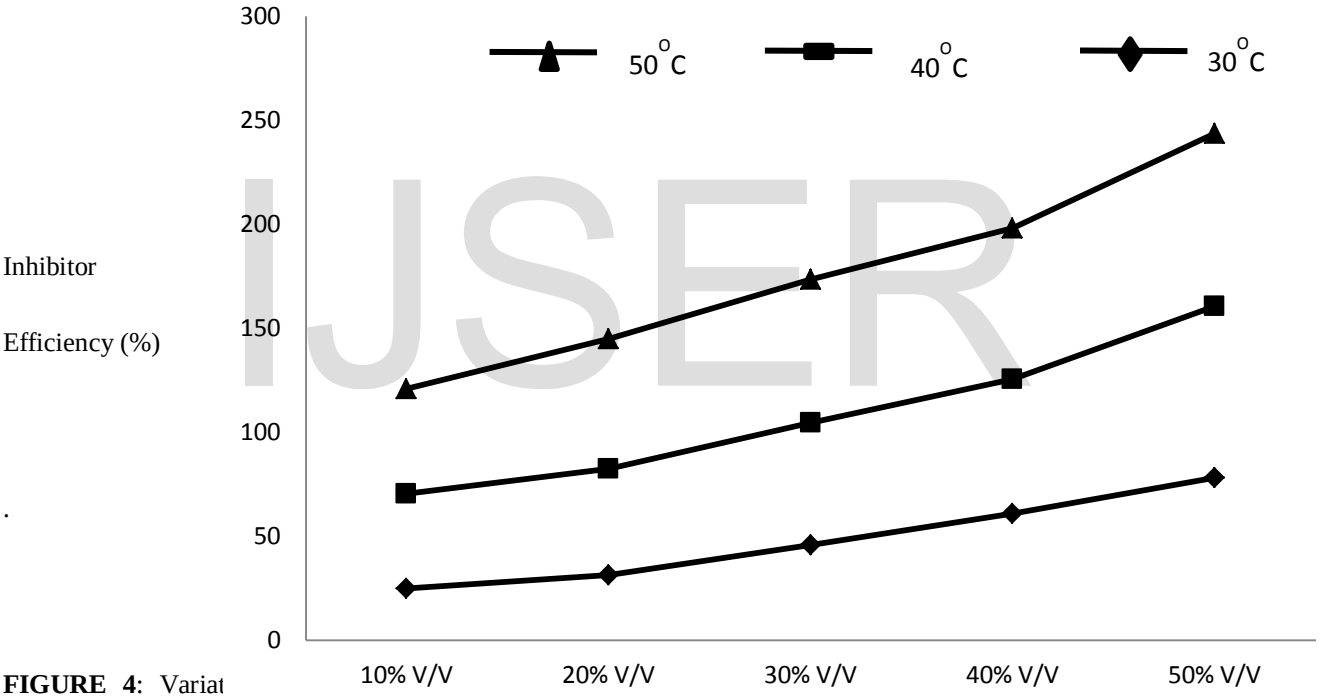


FIGURE 3: Variation of weight loss with time for aluminum coupons in 0.5M hydrochloric acid solution containing different concentrations of bitter kola extract at 50°C.

3.2 Effect of concentration increase on the inhibition efficiency of Bitter kola extract

Fig 4 portrays an increase in inhibition efficiency of bitter kola extract as the concentration of extract increases in the acid solution. This can be observed from the upward progression of all three temperatures.



.

FIGURE 4: Variat

hydrochloric acid solution containing bitter kola extract at three different temperatures.

3.3 Effect of temperature on the inhibition efficiency of bitter kola extract

The effect of increase in temperature on the inhibition efficiency of bitter kola extract is also displayed graphically in fig 4. We can observe from the graph that as the reaction temperature is increased from 30^0C to 40^0C and to 50^0C the inhibition efficiency increases.

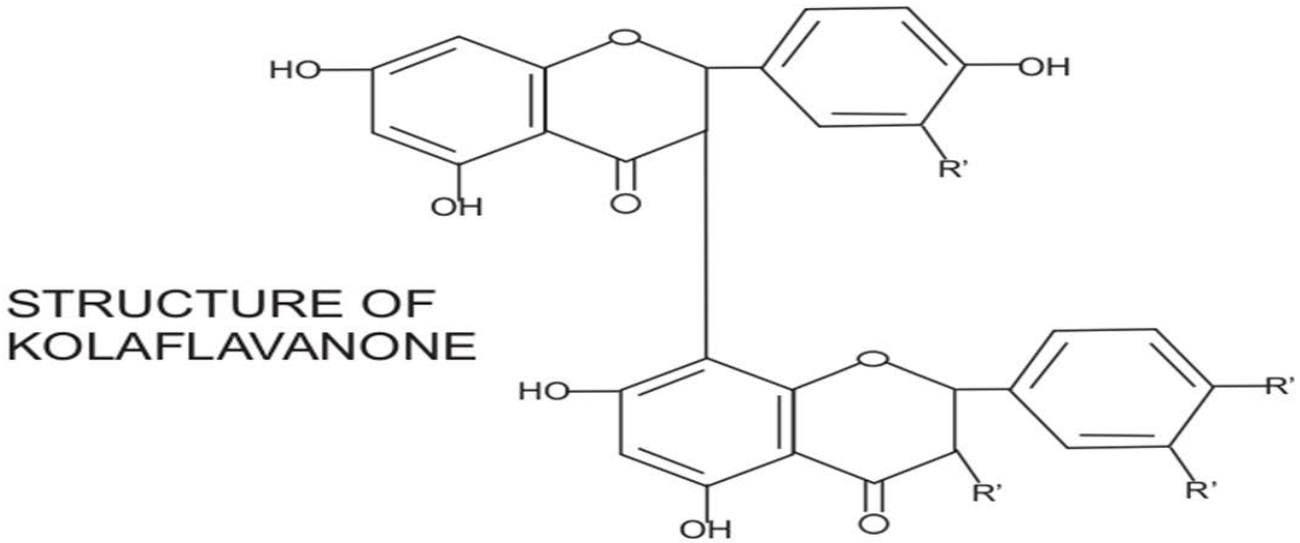
Thus, it is appropriate to say that increasing temperature favours the inhibition efficiency of bitter kola extract on aluminium in HCl.

Table 1: Corrosion rate, inhibition efficiency and surface coverage of bitter kola extract on aluminium at 50^0C for 210 min immersion period.

Concentration (%v/v)	Corrosion rate (mm/yr)	Inhibition efficiency (n%)	Surface coverage (Θ)
0.0	1.38	-	-
10	0.68	50.68	0.51
20	0.54	62.32	0.62
30	0.42	69.05	0.70
40	0.40	72.65	0.73
50	0.23	82.96	0.83

3.4 ACTIVE COMPONENT OF THE EXTRACT

The active constituent of garcinia kola is dimeric flavonoid molecules fused together-biflavonoid. Biflavonoid are



STRUCTURE OF KOLAFLAVANONE

	R_1	R_2	R_3	R_4
GB1	OH	H	OH	H
GB2	OH	H	OH	OH
KOLAFLAVANONE	OH	H	OCH_3	OH

From the structural point of view, bitter kola is a flavonone that contains several electron rich sites for its adsorption onto the metal surface. The various oxygen atoms at the rings are electron rich and they also serve as adsorption sites to the metal to effect corrosion inhibition.

Adsorption Mechanism: The inhibitor must have been chemically adsorbed into the metal surface from the temperature effect on the % inhibition efficiency.

4.0 CONCLUSION

Bitter kola was found to be a highly efficient ecofriendly inhibitor for aluminium in 0.5M HCl solution reaching about 82.96% at 50%v/v and 50^0C a concentration considered to be very moderate. Bitter kola is a potential corrosion inhibitor. The percentage efficiency in the presence of inhibitor increases with temperature which indicates a chemical adsorption of the inhibitor molecule on the metal surface.

REFERENCES

1. E.I. Ating, S.A. Umoren, I.I. Udousoro, E.E. Ebenso, "Leaves extract of Ananas-Sativum as green inhibitor for aluminium in hydrochloric acid solutions," Green Chemical Letters Review, III (2), pp. 61-68, 2010.

2. O.K. Abiola, **"**Inhibition of the corrosion of mild steel in Hydrochloric acid by (4-amino-2-methyl-5-pyrimidinyl methyl through acetic acid) and its precursor," Journal of Corrosion Science and engineering, III, pp.21- 34, 2002.

3. A. Hamdy, Sh. Nour, El-Gendy, "Thermodynamic, adsorption and electrochemical studies for corrosion inhibition of carbon steel by henna extract in acid medium," Egyptian Journal of Petroleum, XXII, pp.17-25, 2013.

4. N.O. Eddy, E.E. Ebenso, "Adsorption and inhibitive properties of ethanol extracts of Musa sapientum peels as green corrosion inhibitor for mild steel in H_2SO_4," Journal of Pure Applied Chemistry, II (6), pp. 46-54, 2008.

5. N.C. Oforka, K.O. Orubite, "Inhibition of the corrosion of mild steel in hydrochloric acid solutions by the extracts of leaves of Nypa Fruiticans Wumb," Material Letters, LVIII, pp. 1768-1772, 2004.

6. T. Ogunmoyole, O.O. Olalekan, O. Fatai, J.O. Makun, I.J. Kade, "Antioxidant and Phytochemical Profile of aqueous and ethanol extract of Garcinia Kola," Journal of pharmacognosy and phytotheraphy, IV (5), pp. 66 – 74, 2012.

7. P.C. Okafor, V.I. Osabor, E.E. Ebenso, "Inhibitive action of ethanol extracts on Garcinia Kola for the corrosion of mild steel in H_2S0_4 solutions," Pigment and Resin Technology, XXXVI, pp. 299-305, 2007.

8. P.C. Okafor, E.E. Oguzie "Inhibitive action of ethanol extracts on Garcinia Kola for the corrosion of aluminium in H_2SO_4 solutions," International Journal of Applied Chemical Sciences, II (1), pp. 1-10, 2007.

9. V.B. Braide, "Inhibition of drug metabolism by flavonoid extract (Kolaviron) of Garcinia Kola seeds in the rats," Phytotherapy research, V, pp. 38-40, 1991.

10. A.O. James, O. Akaranta, "The inhibition of corrosion of zinc in 2.0M Hydrochloric acid solution with acetone extract of red onion skin," Journal of Pure and Applied chemistry, III (11), 212-217, 2009.