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SHORT COMMUNICATION

Evaluation of the corrosion inhibition effect of *Ipomoea batatas* leaves extract on mild steel in sulphuric acid

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ABSTRACT

The inhibition of mild steel corrosion in 1 M sulphuric acid media by ethanolic extracts of *Ipomoea batatas* was investigated using the gravimetric and gasometric methods. The extracts recorded an inhibition efficiency of 61.1 % and 52.6 % at room temperature for the gravimetry and the gasometry respectively. The inhibition process was initiated by the physical adsorption of the inhibitor extracts to the metal surface and the data obtained fitted very well into the Langmuir adsorption isotherm.

***Keywords*:** Gravimetry, Gasometry, *Ipomoea batatas*, Ethanolic extract of *Ipomoea batatas* leaves (EEIBL), Langmuir Isotherm

1. INTRODUCTION

Metal surfaces on exposure to air, water, acids and bases tend to wear away as a result of corrosion reactions. Over the years, several methods of combating the menace have been discovered, such as the use of metal paints, electroplating and inhibitors. Corrosion inhibitors are substances that reduce or eliminate the corrosion reaction when introduced in small quantities into the corrosive medium (Ahmad and Quraishi, 2010). Inhibitors are added to cooling systems, refinery units, oil and gas production units and so on. The uses of synthetic substances as inhibitors lead to the release of toxins into the environment (Oguzie, 2006). As a result, in recent years, there has been a growing interest in the research of discovering eco-friendly inhibitors. Studies have shown that inhibitors prepared from plant leaves, stem and root like Costus afer (Uwah, et al., 2013a), Cnidoscolus acontifolius (Ugi et al., 2016), Phyllantus amarus (Okafor et al., 2008) among others are effective inhibitors for metal dissolution in corrosive media. The present work is aimed at investigating the inhibitive action of the ethanolic extracts of Ipomoea batatas leaves on mild steel corrosion in sulphuric acid media at different temperatures using gravimetric and gasometric techniques.

2. EXPERIMENT / RESULT

2. 1. Sample preparation

The mild steel coupons used were of the following dimensions: 4.0 cm × 0.08 cm × 5.0 cm for weight loss and 2.0 cm × 0.08 cm × 4.0 cm for hydrogen evolution analysis. The coupons were polished using emery papers up to 600grits and 1200grits, degreased with absolute ethanol, rinsed in acetone and air dried and subsequently stored in desiccators prior to use. The dried leaves of *Ipomoea batabas* plant were grounded into powder, and about 200g of the powder was used for extraction which was done continually with 250 cm^3 of absolute ethanol in a soxhlet extractor and 10 g of the crude extract was weighed and digested in 1 L of 0.5 M H_2SO_4 and allowed to stand for about 24hrs. It was filtered and stored.

2. 2. Experimental methods

The gravimetric measurement was carried out at a time interval of 30 minutes at room temperature. Weighed samples were immersed in 200 ml beakers with and without different concentrations of the inhibitor (0.1 g/L, 0.2 g/L, 0.3 g/L, 0.4 g/L and 0.5 g/L) and the weight loss was recorded. The surface coverage was calculated from equation 2.

$$\theta = \frac{Wo - Wi}{Wo} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$CR = \frac{534W}{\rho At} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

where W_0 and W_i are the weight loss values in absence and in presence of inhibitor. The surface coverage θ and corrosion rate (CR) are calculated from equations 1and 2 respectively, W is the weight loss in mg, ρ is the density of mild steel, A is the area of specimen and t is the time immersion (Ugi et al., 2016).

For the gasometric studies, 100 ml solution of the corrodent 1 M H_2SO_4 was introduced into the reaction vessel connected to a burette through a delivery tube. The volume of hydrogen gas evolved was recorded at intervals of 30 min at a temperature of 303, 313, 323 and 333 K for the blank and the inhibitor concentrations of 0.5, 1.0, 2.0, 3.0, and 4.0 g/L. The rate of hydrogen evolved (cm^3/min) was determined from the slope of the graph of volume of gas evolved (cm^3) against time (min). The percentage inhibition efficiency (% I.E) was determined using equation 3.

$$I.E = \frac{RHo - RHi}{RHo} \times 100 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3$$

where R_{Ho} and R_{Hi} are the rate of hydrogen gas evolved per surface area in the absence and presence of inhibitor concentration respectively, I.E is the inhibition efficiency (Uwah *et al.*, 2013b).

2. 3. Result

Table 1. Calculated values of corrosion rate (C_R) of mild steel, surface coverage (Θ) and inhibition efficiencies (%IE) of EEIBL on mild steel in 1 M H_2SO_4 solutions obtained from gravimetric method.

Conc. (g/L)	CR (mg/cm^2/hr)	θ	% IE
Blank	3.401	-	-
0.1	1.965	0.42	42.2
0.2	1.767	0.48	48.0
0.3	1.565	0.54	54.0
0.4	1.501	0.56	55.9
0.5	1.323	0.61	61.1

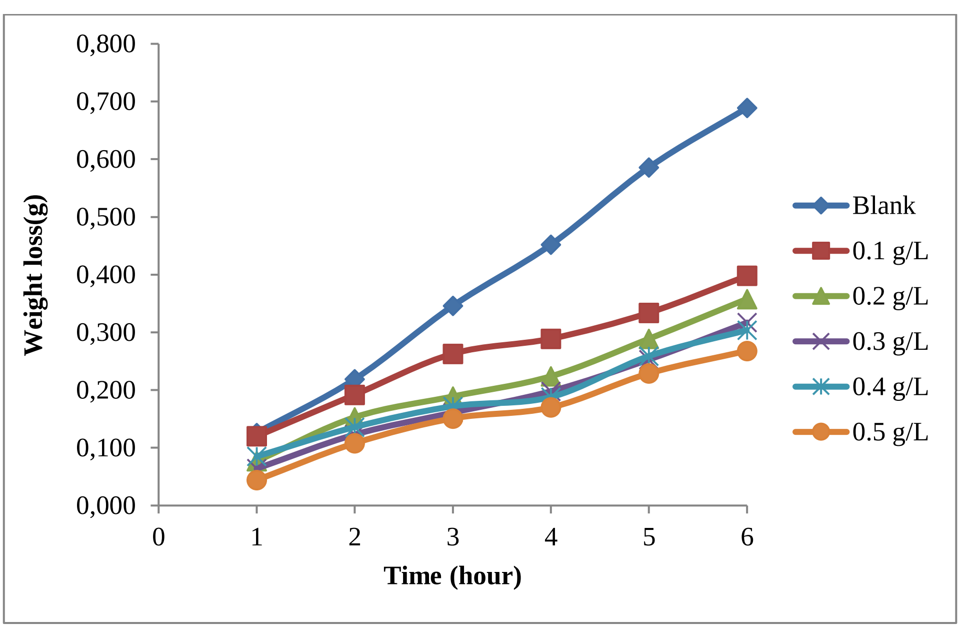

Figure 1. Variation of weight loss with time.

Table 2. Calculated values of corrosion rate (C_R) of mild steel, surface coverage (Θ) and inhibition efficiencies (% IE) of EEIBL on mild steel in 1 M H_2SO_4 solutions obtained from hydrogen evolution method.

Conc. (g/L)	Surface coverage				Inhibition efficiency (%)			
	303 K	313 K	323 K	333 K	303 K	313 K	323 K	333 K
Blank	-	-	-	-	-	-	-	-
0.1	0.28	0.41	0.44	0.45	27.6	41.0	44.0	45.1
0.2	0.29	0.45	0.47	0.58	28.9	44.6	47.2	57.6
0.3	0.40	0.50	0.51	0.64	39.7	50.1	50.8	64.3
0.4	0.48	0.54	0.59	0.66	47.9	54.4	58.9	66.5
0.5	0.53	0.56	0.62	0.68	52.6	56.1	61.7	67.7

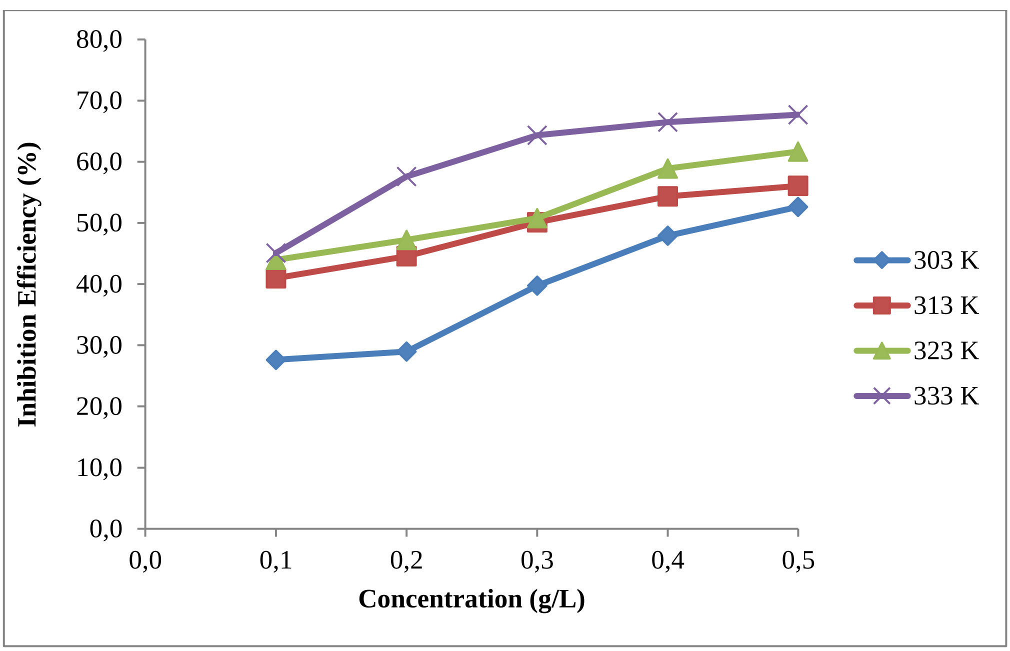

Figure 2. Variation of inhibition efficiency with concentration for the corrosion of mild steel in 1 M H_2SO_4 solution containing various concentrations of EEIBL.

2. 4. *Adsorption mechanism*

The experimental data obtained were fitted into various adsorption isotherms. From the result, it was found that the experimental data fitted the Langmuir adsorption isotherm.

The models may be formulated as equation 4

$$\frac{C}{\Theta} = \frac{1}{K} + C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

where Ө is the degree of surface coverage, C is the extract concentration and K is the adsorption – desorption equilibrium constant. From equation 4, a plot of $\frac{C}{\Theta}$ against C should be linear which clearly show that mild steel corrosion inhibition in H_2SO_4 by EEIBL extract at the temperatures studied obeys Langmuir adsorption isotherm (Chao *et al.*, 2005). The Langmuir adsorption plot for EEIBL is presented in figure 4, while coefficients obtained from Langmuir isotherm plots are shown in Table 3. From the results obtained, R^2 values ranged from 0.887 to 0.999 indicating a high degree of fitness of the Langmuir model of adsorption data.

The slope of unity obtained in this study is an indication that the adsorption of the extract components is approximated by Langmuir adsorption isotherm and that monolayer of the inhibitor species must have been attached to aluminum surface without lateral interaction between the adsorbed species (Oguzie, 2006). The standard free energy of adsorption, ΔG* was calculated from equation 5.

$$\Delta G^*_{ads} = -2.303RT \log(55.5k) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

where the value 55.5 is the molar concentration of water in solution, R is the universal constant and T is the absolute temperature. The values obtained were between -4.391 and -7.263 KJ/mol^{-1}. The negative values of the standard free energy of adsorption (ΔG^*_{ads}), indicates that the inhibitor adsorption on mild steel surface is exothermic and spontaneous. This also suggests a physical adsorption mechanism for the extracts of *Ipomoea batabas*, since the values obtained are below -40KJ/mol (Eddy, 2010).

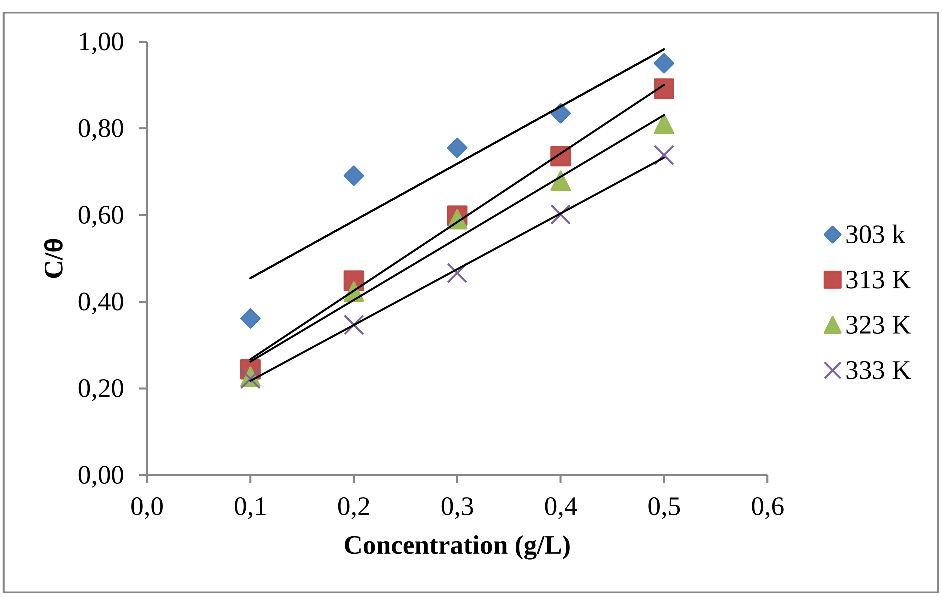

Figure 3. Variation of C/Ө with concentration for the corrosion of mild steel in 1 M H_2SO_4 containing various concentration of EEIBL.

Table 3. Gibbs free energy values obtained from the Langmuir plot

Temp. (K)	Slope	EEIBL K(g/L)	R^2	ΔG^*_{ads} (KJ/mol)
303	1.32	0.322	0.887	-7.263
313	1.583	0.108	0.994	-4.660
323	1.422	0.119	0.98	-5.069
333	1.287	0.088	0.999	-4.391

2. 5. Thermodynamic consideration

Thermodynamic parameter for the adsorption of EEIBL was estimated using the transition state equation, which can be written as

$$Ln\left(\frac{CR}{T}\right) = Ln\left(\frac{NR}{h}\right) + \frac{\Delta Sads}{R} - \frac{\Delta Hads}{RT} \quad 6$$

where, CR is corrosion rate, T is the reaction temperature, N is the Avogadro number, R is the gas constant, h is the Max Planck constant, ΔS_{ads} is the standard entropy of adsorption, ΔH_{ads} is the standard enthalpy of adsorption. From equation 6, a plot of Ln (CR/T) versus 1/T is expected to be linear. Therefore the slope and intercept should be equal to $-\Delta H_{ads}$ /R and (Ln NR/h + ΔS_{ads}/R) respectively. Fig. 4 shows the transition state plots for the alkaloid and non-alkaloid extract of *Ipomoea batatas* (Eddy and Ita, 2011).

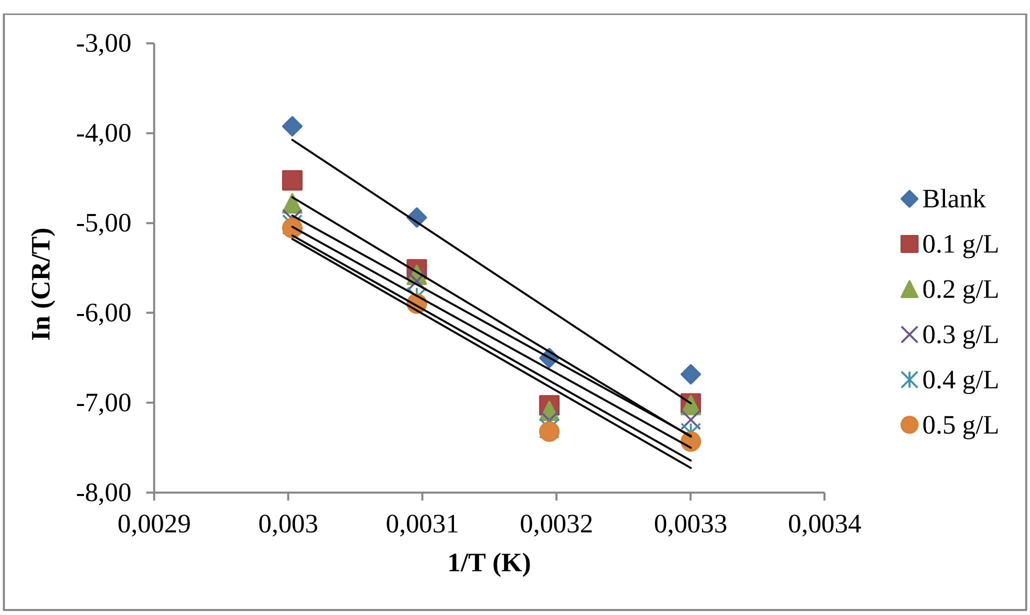

Figure 4. Transition state plot for the ethanolic extract of *Ipomoea batatas*

Table 4. Enthalpy and Entropy values obtained from the Transition state plot

Conc. (g/L)	slope	Intercept	ΔHads(kJ/mol)	ΔSads(kJ/mol)
Blank	9864	25.54	-82.90	-415.87
0.1	8965	22.21	-74.53	-443.55
0.2	8250	19.85	-68.59	-463.17
0.3	8271	19.79	-68.76	-463.67
0.4	8428	20.17	-70.07	-460.51
0.5	8573	20.57	-71.27	-457.19

3. CONCLUSIONS

EEIBL is a good corrosion inhibitor for mild steel corrosion in acidic medium. The inhibition efficiency increases with increase in the EEIBL concentration and reduces with increase in temperature which is a proof of physical adsorption of the extracts to the metal surface. The data obtained from the experiment fitted well into the Langmuir adsorption isotherm.

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