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PROMOTING ECO-FRIENDLY CORROSION INHIBITOR USING BITTER KOLA LEAVES IN CARBON MILD STEEL USING HCL ACIDIC MEDIA

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ABSTRACT

Corrosion of mild steel in HCl was investigated using the weight loss method. The mild steel used was cut into 16 coupons with 5.0 cm x 5.0 cm x 0.2 cm dimensions which were degreased with ethanol and washed with distilled water and finally weighed. The mild steel coupons were exposed to HCl with varied concentrations (0, 10, 25 and 40%) of Garcinia kola extracts used as corrosion inhibitors for 4 hours at 400C and 600C respectively. The result showed that at 400C; the inhibition efficiency of 65.5% was observed at 25 % HCl concentration and 62.9% at 40% HCl concentration while at 600C; inhibition efficiency of 87.7% was at 25% HCl concentration and 88.1% at 40% concentration respectively. It can be concluded that increase in concentration increases the inhibition efficiency. The presence of flavonoid and alkanoids in bitter kola stem is a good inhibitor.

Keywords: Corrosion, Mild steel, Bitter kola, Inhibitor, Agriculture, Temperature

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1. BACKGROUND OF STUDY

Corrosion is the deterioration or destruction of metals and alloys by chemical or electrochemical reactions with its environment [1]. Corrosion prevention by chemical compounds known as inhibitors has been proven to be one of the most feasible, reliable and cost effective methods [2]. Most corrosion inhibitors are organic derivatives consisting of heteroatoms and multiple bonds enabling strong intermolecular attraction and adsorption in the presence of corrosive anions [3]. The use of inhibitors has been adopted in the industries, for a long time now, as a result of its excellent anti-corrosive properties. A corrosion inhibitor is a substance which when introduced in a small concentration to an environment, decreases the corrosion rate of a metal exposed to that environment [4]. Pandian *et al.*, [5] stated that there is positive progress in research, in obtaining natural corrosion inhibitors and the research to achieve this goal is growing as the demand for a greener environment is. Currently, research activities are focussed on finding a replacement for inorganic [6] and organic metal corrosion inhibitors. Plant extracts are one of the sources targeted for the replacement of inorganic and organic inhibitors. Some of these plants extracts are Carica Papaya and Camellia Sinensis Leaves [7]; Cola acuminata and Camellia[8] Saccharum officinarum Juice extract [9]; Groundnut leaves extract [10], Katemfee Seed [11]. This research is aimed at determining the effect of temperature on inhibition efficiency.

2. MATERIALS AND METHODOLOGY

Materials and chemicals were used for the research work and they are listed in this section.

2.1. Materials

i. Bitter kola leaves (*Garcinia kola)* grown and collected from Ekiti State, Nigeria.
ii. Sheets of mild steel coupons of 50 mm x 50 mm x 2 mm dimension.
iii. Aluminum foil.

2.1.1. Chemicals used

i. Hydrochloric acid (HCl), H_2SO_4 and Ethanol.

2.2. Methodology

The procedures involved in carrying out this research are discussed in details in this section. The following steps were taken:-

2.2.1. Preparation of Sample

The sample that was prepared here is the corrosion medium for the mild steel coupons that was used in the calculation of the weight loss of the material. The sample used here are H_2SO_4 and HCl. The experiment was carried out under temperature controlled conditions in water bath.

2.2.2. Preparation of Plant Extracts

Bitter kola leaves of 2 kg were sundried for 14 days to remove the moisture content in the leaves completely. The leaves was first blended with a blending machine available in the laboratory after which it was further grinded with an industrial grinder to powdered form of uniform size. Fine powder of 20 ml obtained was then completely soaked in 200 ml acid solution of sulfuric acid for 3 hours at 90 ^{0}C in a water bath to obtain the pure extract of the leaves. The solution was left to cool and stand for a period of 24 hours so as to decant the extract from the cake. The solution was then filtered to obtain a high yield concentration of the filtrate.

2.2.3. Preparation of Specimen

Mild steel coupons of 2 mm thickness were used in this research. The mild steel was mechanically cut into coupons of equal dimensions of 50 mm x 50 mm each. 16 mild steel coupons of this dimension were used in this research. The surface area treatment was done by degreasing using absolute ethanol and then allowed to dry.

2.2.4. Weight Loss Measurement

The initial weight of fifteen (16) mild steel coupons was taken using the weighing balance. The percentages of the inhibitors that were added to the acid varied by concentration of 0, 10, 25 and 40 % at temperatures of 40 and 60 ^{0}C. Then, the coupons were immersed in the solutions of different concentrations of the inhibitor (0, 10, 25 and 40 %) at 40 and 60^{0}C each in their respective water baths. Final weight measurements of the mild steel coupons immersed in the Hydrochloric acid medium were taken after 4hrs at temperatures 40 and 60^{0}C separately. A total of 16 readings were taken at each interval using a weighing balance.

The Inhibition efficiency (I.E.) of the corrosion rate (C.R.) of the mild steel were determined using equations 1 and 2:

$$\text{I.E.} = \left(\frac{CR1-CR2}{CR1}\right) \text{ x } 100\ \% \quad (1)$$

$$\text{C.R.} = \frac{87.6 \text{x} \Delta W}{A \text{x}\ T} \quad (2)$$

Where, W_1= Weight of mild steel before immersion.

W_2= Weight loss of mild steel after immersion.

CR_1= Corrosion rate of the mild steel in the absence of inhibitors.

CR_2= Corrosion rate of the mild steel in the presence of inhibitors.

A= Surface area of the coupon in cm^2

$\Delta W = W_1 - W_2$

2.3. Procedure

The mild steel specimens were immersed into the beakers of concentrations of the inhibitor (0, 10, 25 and 40%) covered with aluminum foil and placed in the water bath at 40 and 60^{0}C temperatures separately and the inhibition efficiencies were determined.

The specimens which have been degreased were used in the test solutions. First, for sulfuric acid and later for hydrochloric acid, with the result compared to determine the medium that has the higher corrosion efficiency and at what temperature would be a better medium. A total of sixteen (16) readings were recorded for a particular acid medium. The weights of the specimens were taken before and after the 4hrs run using the weighing scale. The samples were however cleaned and dried before taking their final weights.

2.4. Phytochemical Analysis

The phytochemical analysis of the bitter kola leaves were carried out in the laboratory to determine the leaves chemical constituents which includes alkaloids, saponins, tanins and flavonoids.

2.5. Surface Examination

The Fourier Transform Infra-red (FT-IR) was used in examining the functional groups present in the inhibitor.

3. RESULTS AND DISCUSSIONS

The results on the experiments done with the extracts from bitter kola leaves are reported and discussed in this section.

3.1. Phytochemical Properties of Bitter Kola Leaves

The phytochemical properties of the bitter kola leaves which were determined have the results obtained shown in Table 1.

Table 1 Phytochemical properties of bitter kola leaves

S/N	Parameters	Results
1	Alkaloids	+
2	Saponins	-
3	Tanins	-
4	Flavonoids	+++

NB: - indicates the absence of the parameter while + shows the presence in mild quantity and +++ shows the presence in a much larger quantity of the parameter.

3.2. Weight Loss Method

Weight Loss Measurements were conducted under total immersion using 250ml capacity beakers containing 0, 15, 25 and 40 % concentration of inhibitor using HCl at 40 and 60 ^{0}C in a water bath. The measurements were taken before and after heating the coupons in the water bath for 4 hours. Table 2 shows the results of weight loss measurement, corrosion rate and inhibition efficiency data obtained. In addition, Figures 1 and 2 shows the graphs of inhibition efficiency against inhibition concentration in HCl at 40 and 60 ^{0}C respectively.

Table 1 Weight loss, Corrosion rate and Inhibition efficiency of mild steel in HCl at 40^{0}C

Inhibition Concentration (%)	Initial (g)	Final (g)	Weight Loss (g)	Corrosion Rate (g/m3.hr)	Inhibition Efficiency (%)
0%	26.3	25.69	0.61	0.068071338	
10%	25.55	25.31	0.24	0.026782166	60.6557377
25%	23.86	23.65	0.21	0.023434395	65.57377049
40%	24.97	24.77	0.2	0.022318471	67.21311475

Table 2 Weight loss, Corrosion rate and Inhibition efficiency of mild steel in HCl at 60^0C

Inhibition Concentration (%)	Initial (g)	Final (g)	Weight Loss (g)	Corrosion Rate (g/m3.hr)	Inhibition Efficiency (%)
0%	25.36	22.99	2.37	0.264473885	
10%	25.18	24.84	0.34	0.037941401	85.65400844
25%	24.74	24.45	0.29	0.032361783	87.76371308
40%	25.56	25.28	0.28	0.03124586	88.18565401

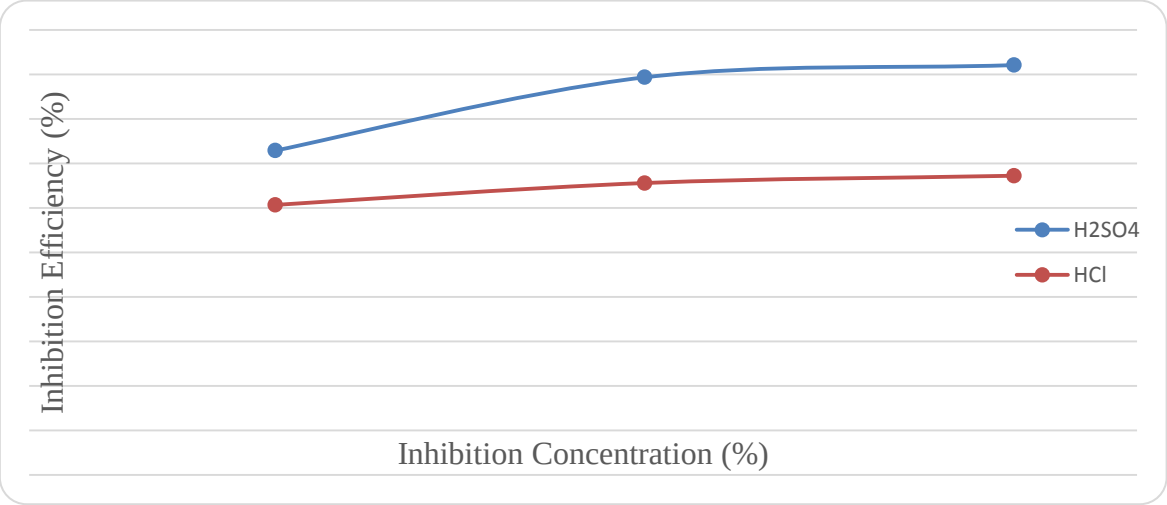

Figure 1 Graph of Inhibition Efficiency of *Garcinia kola* leaves against concentration in 1M H_2SO_4 and 1M HCl acidic media at 40^0C

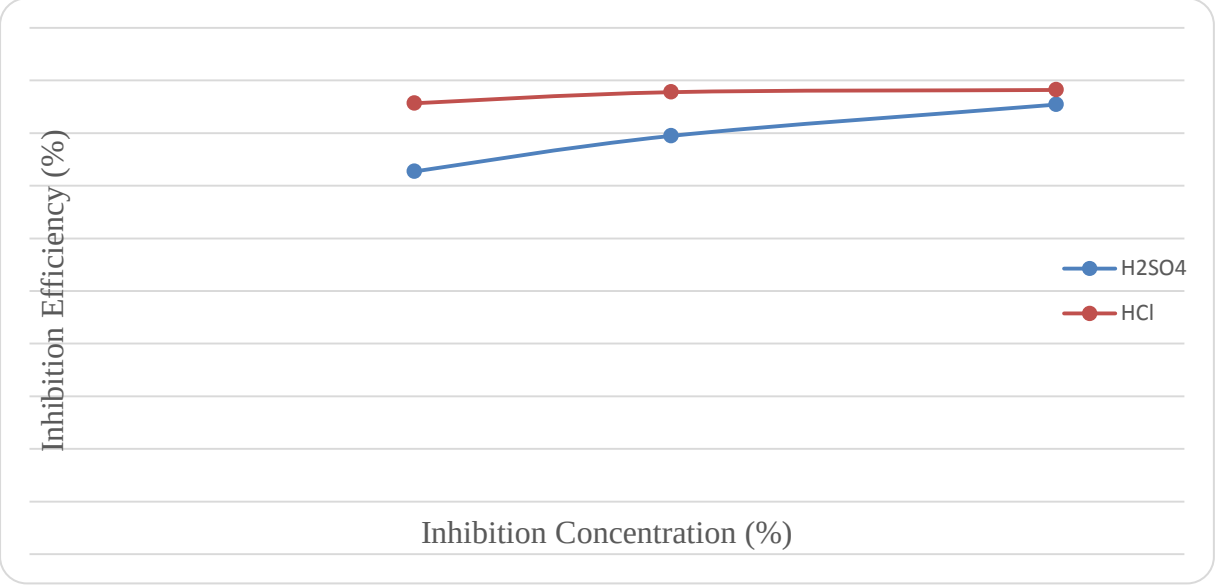

Figure 2 Graph of Inhibition Efficiency of *Garcinia kola* leaves against concentration in 1M H_2SO_4 and 1M HCl acidic media at 60^0C.

3.3. Discussion of results

From the results of the phytochemical analysis of the bitter kola leaves, it showed that bitter kola leaves has metaproperties that are responsible for inhibiting corrosion of metals as shown in the graphs in Tables 1 and 2 and the figures in Appendix A. However; in Fig. 2, it was observed that the inhibition efficiency of *Garcinia kola* increased with an increase in temperature in the HCl acidic medium from 67.21 to 88.19%.

4. CONCLUSION

It was observed that corrosion rate decreased from 0.37 (0% inhibitor concentration) to 0.03 (40% inhibitor concentration) and that increase in temperature, increases the inhibition efficiency.

It can be concluded that Bitter Kola leaves is a good corrosion inhibitor in 1M HCl from the findings reported.

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APPENDIX A

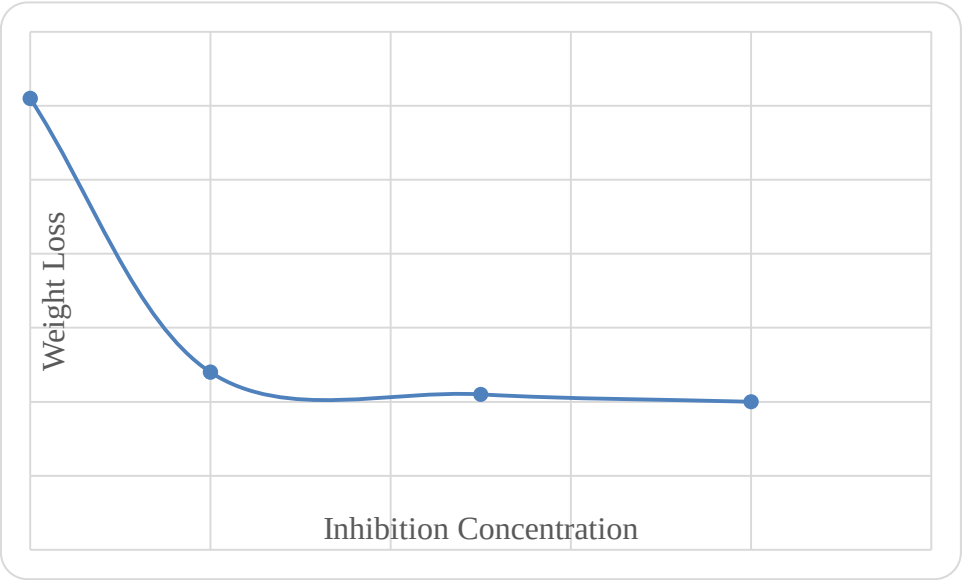


Figure (a) Graph of Weight loss against Inhibition Concentration in HCl at 40^0C

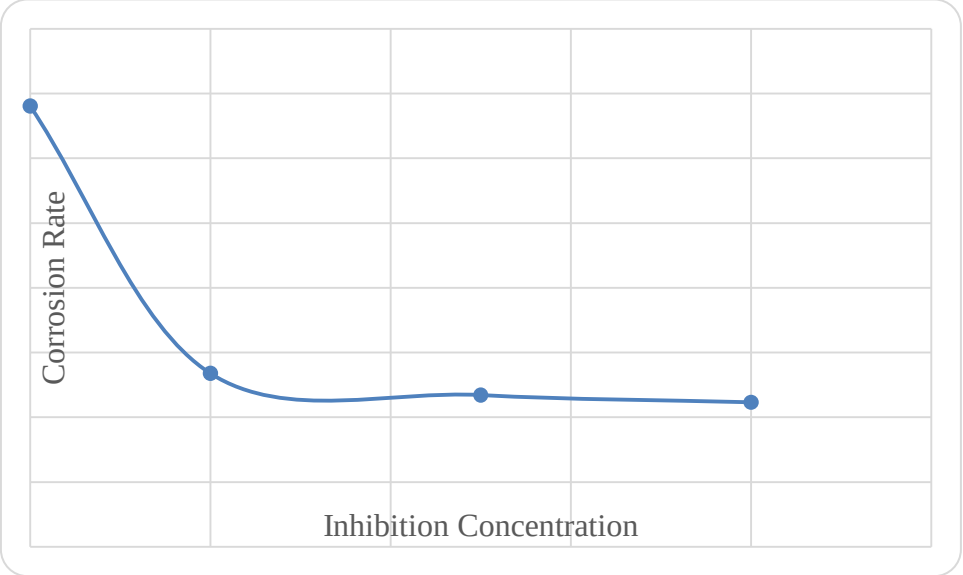
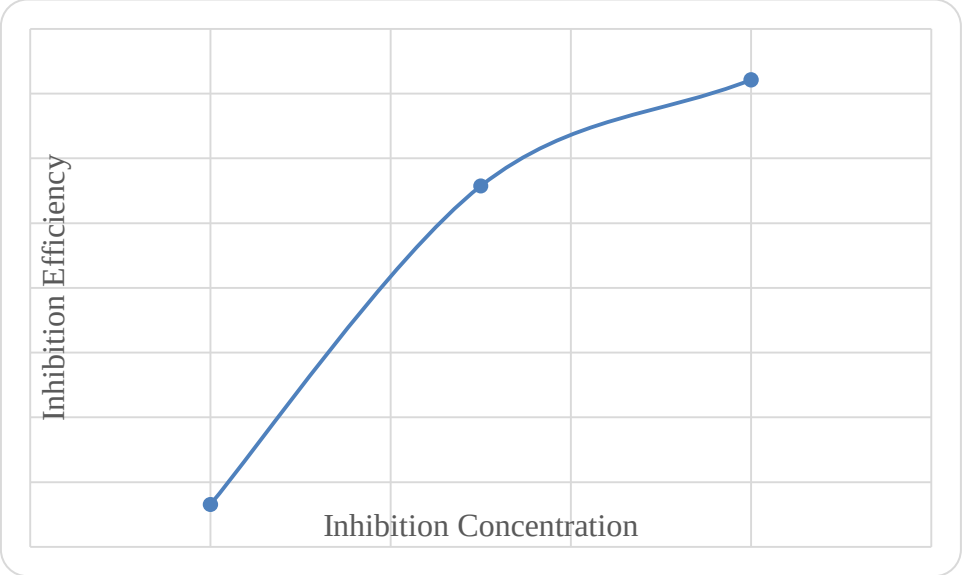


Figure (b) Graph of Corrosion rate against Inhibition Concentration in HCl at 40^0C



Figure(c) Graph of Inhibition efficiency against Inhibition Concentration in HCl at 40^0C

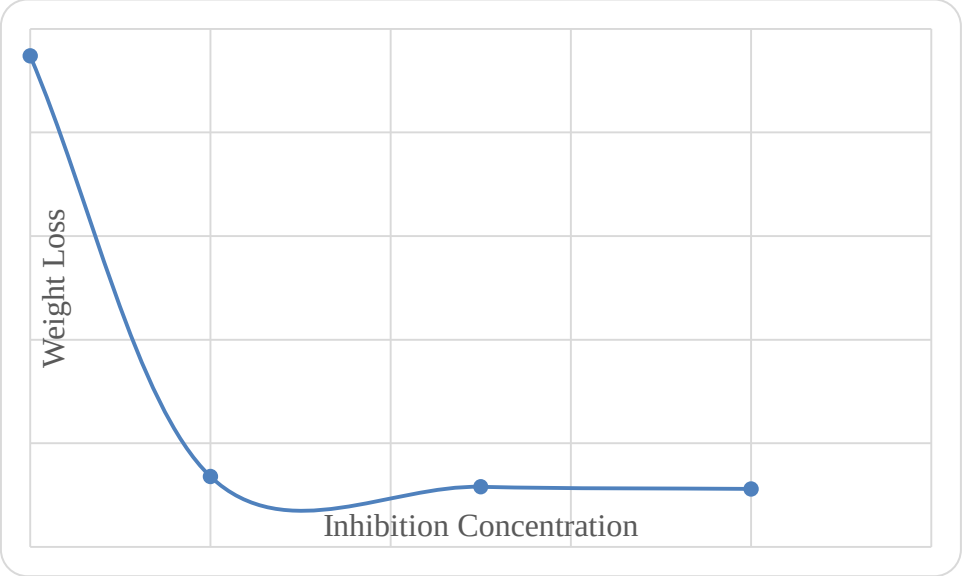


Figure (d) Graph of Weight loss against Inhibition Concentration in HCl at 60^0C

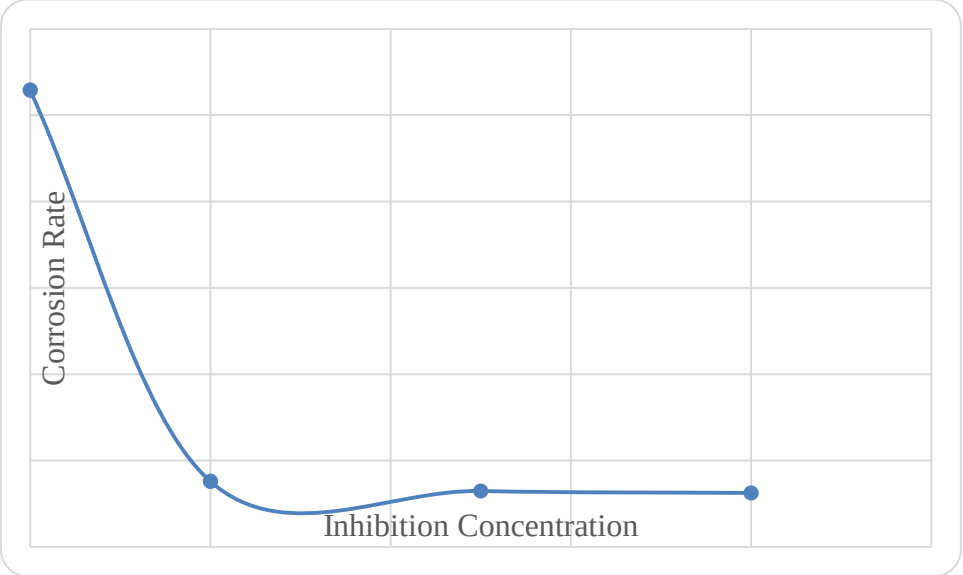


Figure (e) Graph of Corrosion rate against Inhibition Concentration in HCl at 60^0C

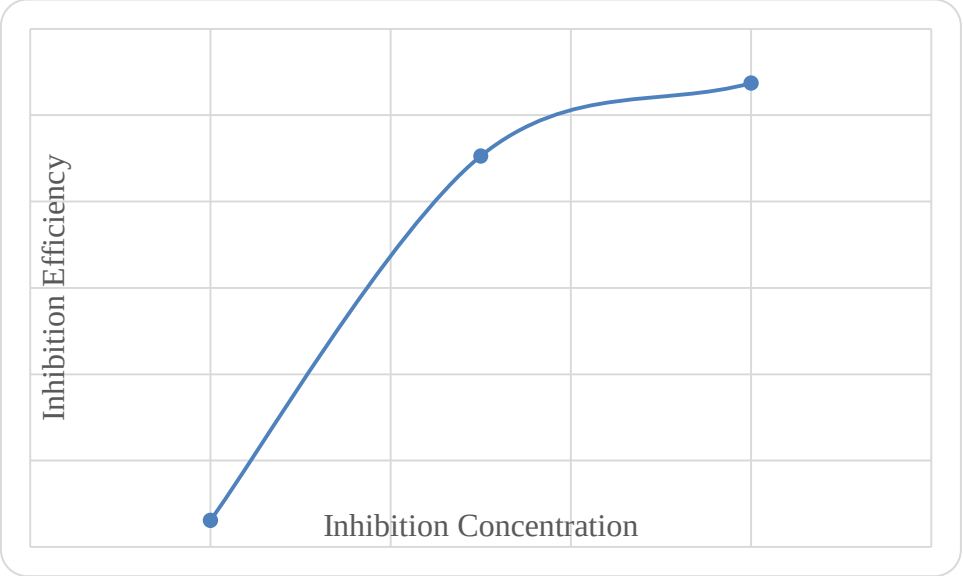


Figure (f) Graph of Inhibition efficiency against Inhibition Concentration in HCl at 60^0C