GSJ: Volume 8, Issue 4, April 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

CORROSION INHIBITION OF MILD STEEL IN HYDROGEN CHLORDE(HCl) SOLUTION USING MORINGA LEAF EXTRACT

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ABSTRACT

Corrosion inhibition capability of mild steel in hydrochloric acid by moringa leaf extract observed using weight loss and electrochemical methodshowedthat the leaf extract act as a good corrosion inhibitor for mild steel in all concentrations of the extract. The inhibition action depends on the concentration of the moringa leaf extract in the acid solution. Results for weight loss and electrochemical measurements indicate that inhibition efficiency increases with increasing inhibitor concentrations. The adsorption of moringa leaf extract on the surface of the mild steel specimens obeys Langmuir adsorption isotherm. The result shows through electrochemical method that the extract concentrations of 1g, 2g, 3g, 4g and 5g produced 90.86%, 93.11%, 94.99%, 95.62%, and 96.54% efficiencies respectively. Also through weight loss method, concentration of moringa leafs extract of 0.2g, 0.4g, 0.6g, 0.8g and 1.0g produced 47.37%, 88.57%, 78.91%, 91.18% and 86.02% respectively.

Keywords: Corrosion, Inhibitor, Hydrogen chloride, Moringa leaf extract, Moringa, Electrochemical

INTRODUCTION

Corrosion is a natural process, which converts a refined metal to a more chemically stable form, such as it oxide, hydroxide, or sulphide. It is the gradual destruction of material (usually metals) by chemical and or electrochemical reaction with their environment. Corrosion engineering is the field dedicated to controlling and stopping corrosion.

Corrosion inhibitor is a substance when added to a corrosive environment significantly decrease the rate of corrosion attack caused by the environment. They are added in small quantity to pickling acids, acid stimulation fluids, cooling waters, oil and gas production streaks either continuously or intermittently to control corrosion. Most proposed inhibitors fall into one of the following categories;natural plant or animal products, industrial by-product or pure chemical compounds. The use of organic inhibitors is one of the most practical methods for protecting metals against corrosion and is becoming increasingly popular, according to recent studies. The existing data show that organic inhibitors act by adsorption and film formation on the surface of metals. The adsorption of organic inhibitors on the metal surface can change the corrosion resistance properties of metals. Earlier studies have shown that organic compounds having heteroatom with a high electron density, such as phosphorus, sulphur, nitrogen and oxygen, or those containing multiple bonds, which are organic inhibitor on the metal surface can change the corrosion resistance properties of metal. Earlier studies have shown that organic compounds having heteroatom with a high electron density, such as phosphorus, sulphur, nitrogen and oxygen, or those containing multiple bonds, which are considered as adsorption centres, are effective inhibitors of the corrosion of metals (Abdel-Gabber et al., 2005). The adsorption of an organic inhibitor is generally on the metal surfaceboth physically and chemically, this reduces the reaction area susceptible to corrosion attack. In 2005, El-Etre et al also researched into corrosion inhibition of carbon steel, nickel and zinc in acidic, neutral and alkaline solution using lawsonia extract as an inhibitor and found the inhibition efficiency to be 95percent. Noor (2007) examined the temperature effect on mild steel corrosion in 2.0M of HCl and H_2S0_4 in the presence of 'Aqueous Extract of Fenugreek Leaves' (AEFL) with help of gravimetric method and he achieved an inhibition efficiency of 92.2percent.

EL-Etre (2007) reported the inhibitive action of aqueous extract of olive leaves towards to corrosion action of carbon steel in 2M HCl solution using weight loss measurements, tafel polarization and cyclic voltammetry and found the inhibition efficiency to be 93 percent.In 2009, Shyamala and Arulanantham researched into the inhibition effect of eclipta Alba in 1M of hydrochloric acid on corrosion of mild steel using weight loss, potentiodynamic polarization and impedance method. The ecliptaAlbawere found to be effective corrosion pickling inhibitor with inhibition efficiency of 99.6 percent.

The behaviour of the inhibitive effect of lupine (lupines albus L.) extract on the corrosion of IM sulphuric, and 2M hydrochloric acid was studied by Bothi Raja and Sethuraman(2009), using potentiodynamic polarization and electrochemical impedance spectroscopy(EIS) techniques. The inhibition efficiency was 86.5perccent.

In 2010, Eddy and Ebenso, studied the inhibition of the corrosion of mild steel by ethanol extract of musasapientum peels in H_2SO_4gasometric and thermometric methods. The result of the study revealed that the different concentration of ethanol extract of sapientum peels inhibits mild steel corrosion and the inhibition efficiency was 71percent.

P.B. Raja and M.G. Sethuraman in 2008 looked into the inhibition efficiency of cotulacinerea, retamaretam and Artemisia herba. Investigation of theplant extracts on the corrosion of x52 mild steel in aqueous 20% (2.3M) sulphuric acid. He examined Weight loss determination and electrochemical measurements and the inhibition efficiency was67%.

Evaluation of natural oil extracted from pennyroyal mint (menthe pulegium, PM) as the corrosion inhibitor of steel in molar hydrochloric using weight loss measurements, electrochemical polarization and EIS methods byBouyanzeretal (2006). The imhibition efficiency was 80%.

Investigation of the inhibition effect of zanthoxylumalatum plant extract on the corrosion of mild steel in 5% and 15% aqueous hydrochloric acid solution by weight loss method and electrochemical impedance spectroscopy (EIS) methods. The effect of temperature on the corrosion behaviour of mild steel in 5% and 15% HCl with the addition of plant extracts in the temperature range 50-80℃. Surface analysis. (SEM, XPS and FT-IR) was also carried out to establish the corrosion inhibitive property of this plant extract in HCl solution by Chauhan and Gunasekaran(2007) and the inhibition efficiency was found to be 85 percent.

Khamis and Alandis (2002) have successfully used electrochemical impedance spectroscopy to evaluate the performance of some compounds that is thyme, coriander, hibiscus, anis, black cumin and garden cress. The AC measurement showed that the dissolution process is activation controlled. Potentiodynamic polarization curves indicate that the studied compounds are mixed type inhibitors. Thyme, which contains the powerful antiseptic thymol as the active ingredient, offers excellent protection for steel surface.

In this paper, evaluation of the corrosion rate of mild steel in aqueous HCl media using morringa leaf extract as inhibitor, theelectrochemical method was adopted usingcalculations of inhibition efficiencies of varied extract concentrations thus ascertaining the concentration that produce highest inhibitive efficiency.

Materials and Method

The materials used in connection with the electrochemical machine modules include electrodes (the working and the reference electrode), the coupon, the inhibitor (moringa extract), polyester resin, addner, accelerator, moulding cup, flexible wire, aluminium foil, electricity, computer system and the electrochemical machine.

Test specimen preparation

Mild steel bought from African steel in Ogijo in Ogun state and a spectro-analysis performed on the mild steel with the aid of a spectrometer to determine the percentage composition of the steel.

Cutting of the steel into six places of size 10 x 20mm and were abraded with a series of emery paper and washed thoroughly with distilled water and later rinsed with acetone and allowed to dry in air, this is to ensure proper surface cleanliness of the specimen before immersion. AttachSpecimens to the naked part of small wires with the aid of an aluminium foil and placed inside the moulding cup. Mix the polyester resin with the addner in a bowl, after mixing it very well, add accelerator to mixture and pour inside the moulding cup containing the specimen for some minutes to solidify to the shape of the cup. Then, remove the formed shape and grind to expose the specimen in the mould.

Plant preparation

The procedure for the preparation of the leaves extract is similar to that reported by Odusote and Ajayi (2013). Fresh green MoringaOleifera leaves obtained from the surroundings of the Federal Polytechnic Ado Ekiti, and then washed, cut into pieces, and air dried before pulverization. 200grams of the pulverized leaves were soaked in 250cm^{3}of methanol in a conical flask. Filter the resulting solution, leave for 48 hours and read. Subject the filtrate to evaporation at room temperature to obtain the extract. The inhibition test solutions were prepared from the extract to obtain 0.2g, 0.4g, 0.6g, 0.8g and 1.0g in 1 litre of 1M hydrogen chloride (HCl).

Preparation of the media

1M of concentrated hydrochloric acid was prepared with distilled water, out of which the various HCl media for the coupons was prepared

Electrochemical measurements

Perform the open-circuit potential (OCP) experiments were d using a model AFCBP1 Versastat 4, a product of Pine Instrument Company. The electrochemical instruments consisted of the Platinum counter electrode kit, reference electrode (silver chloride, single JXN, pin connector, 14/20 adapter), 5-neck glass RDE cell of 150 ml, fixed shaft (non-rotating), E4TQ change Disk RDE tip and E4TQ replacement holder

The set-up of the instrument contains the cell and the three electrodes as shown in figure 3.1 above. The three electrodes are the working electrode (red colour), the reference electrode (white colour) and the counter electrode (green colour). The working electrode is the specimen we are finding it corrosion rate, the counter electrode it is the one in charge of voltage measurement, while the reference electrode serves as standard for measurement, it is a more conductive metal than the working electrode and the measurement base on the conductivity of the reference electrode used. It can be silver, platinum or graphite. The one used in this experiment is platinum. Connect the specimento the working electrode and separately dip it inside the solution in the beaker together with the counter and reference electrode while a current passed through it. After some time, the time taken, the open circuit potential, corrosion potential, corrosion current and the corrosion rate on the monitor is noted. Perform the procedure on the blank (i.e. solution without inhibitor), 1.0g, 2.0g, 3.0g, 4.0g and 5.0g of the inhibitor in the solution andtabulate their respective result on the monitor.

Weight loss measurements

Cutcoupon mechanically into 10×20mm into six places and weighed on a 4-decimal places digital analytical weighing balance to know the initial mass.

Then, mix the prepared acid solution was with different quantity of the inhibitor in six deferent beakers with one of the solution as the control (i.e. beaker without inhibitor) and labelled.Immerse a weighed mass wasin the solution for 3 days. Takecoupons out, clean with distilled water, degreased with acetone, dried and weighed. Return weighed coupons to their respective media and the process continued for 25 days. The weight loss of the mild steel coupons was obtainedand corrosion rates the corrosion rate (C_R) was calculated using the following equation

$$C_R = \frac{K\Delta W}{ADt} \qquad (1)$$

k is corrosion constant, ΔW is the weight loss of the mild steel coupon, A is the total area of the coupon in square cm, D is the density of the coupon, and t is the immersion time. With the calculated corrosion rate, the inhibition efficiency ($\eta\%$) was calculated using equatio2:

$$\eta\% = (1 - \frac{C_{R(i)}}{C_R}) \times 100 \qquad (2)$$

$C_{R(i)}$is the corrosion rate of inhibited specimen and C_R is the corrosion rate of uninhibited specimen

Results and discussion

Table 1: composition of the mild steel

Elements	% composition
C	0.05
Mn	1.13
Si	0.05
P	0.91
S	0.85
Cu	0.09
Pb	0.15
Ve	0.13
Mo	0.08
Fe	96.56

The result in the table above shows the sample of the steel contain 0.05% of carbon and 96.56% iron. This is an indication that the steel is low carbon steel because of the percentage carbon rating.

Characteristics of moringaolefera leafs

The EDS (energy-dispersed x-ray spectroscopy) results obtained were in agreement with proposed theoretical values. The major constituents of the inhibitor extract are oxygen (O), sulphur (S), carbon (C) and calcium (Ca). These polar functions of sulphur and oxygen in the leaf extract of the organic substances suggest active inhibitive properties for mild steel within an acidic environment

Table 2: Electrochemical output

Qty of inhibitor (g)	Anodic current(mV)	Cathodic current (mV)	Potential (mV)	corrosion current I (µA)	Corrosion rate (mmpY)	Efficiency(η) %
0	84.374	130.384	-457.14	677.332	7.8595	-
1	67.564	153.382	-405.287	61.886	0.71811	90.86
2	73.017	156.928	-373.025	46.674	0.54159	93.11
3	78.158	137.943	-413.608	33.952	0.39397	94.99
4	81.224	161.458	-396.514	29.641	0.34395	95.62
5	72.676	86.355	-429.538	23.43	0.27187	96.54

The electrochemical machine works on the principle of Faraday's second law of electrolysis, which states that 'The current passing through a conductive material is proportional to the amount of chemical deposited on that material

Table2 above shows the corrosion rates of the specimen in different grams of the inhibitor in the acid solution. The solution without inhibitor (i.e. blank) has the highest corrosion rate and the corrosion rate decreases as the moringa extract increases in the solution.

The table also shows the efficiency of the extract at different amount of the inhibitor in the solution. The efficiency increases with the amount of extract in the solution.

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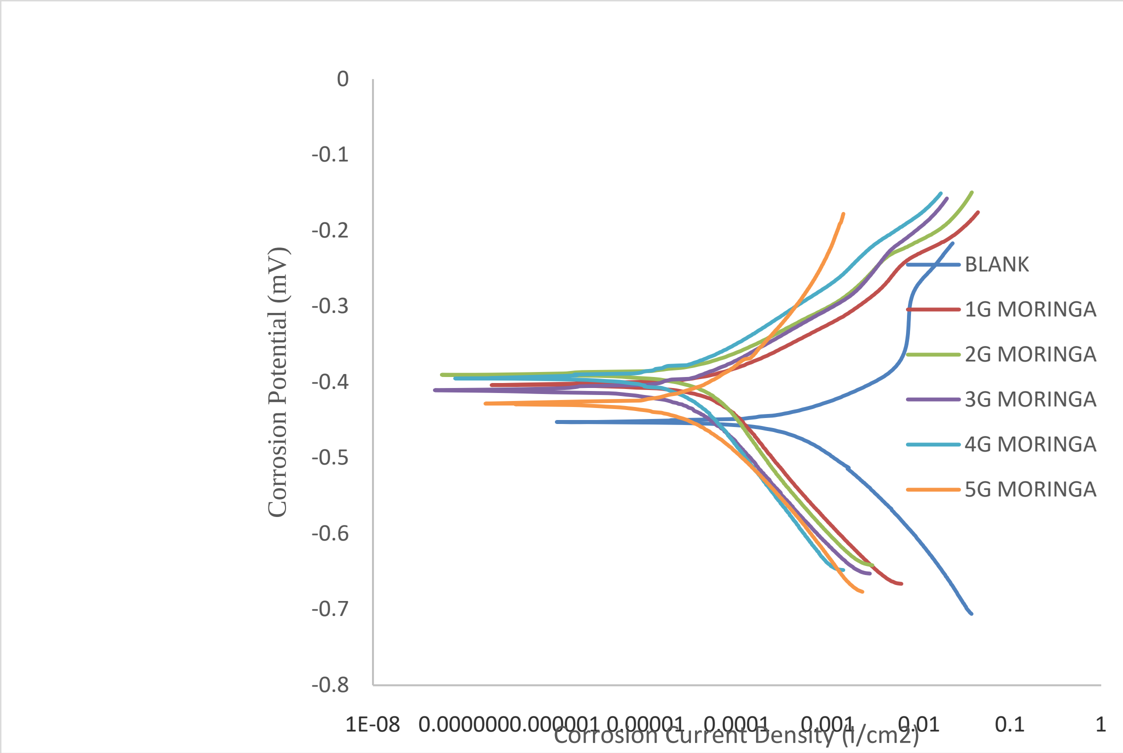

Fig. 1 Graph of corrosion potential against corrosion density

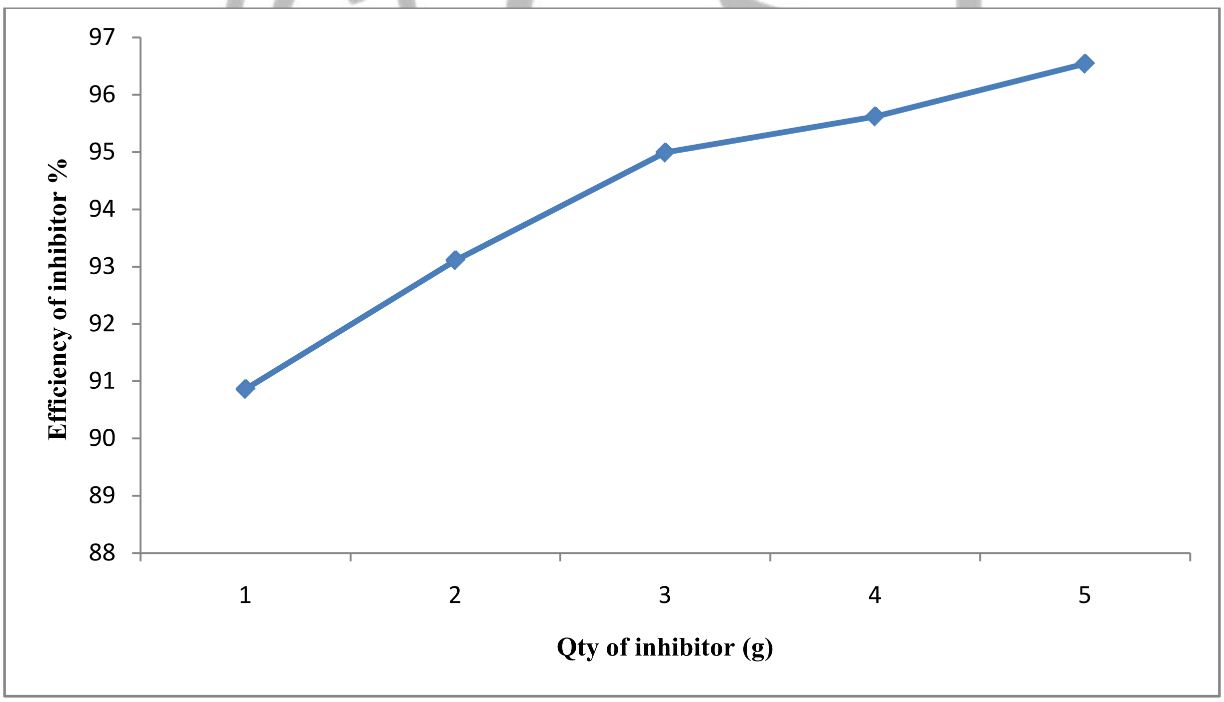

Fig. 2 graph of efficiency against the amount of inhibitor in grams

Figure 1shows the corrosion rate of the mild steel in different amount of the inhibitor in the acidic solution. The blank curve is the graph of coupon without inhibition and the point of intersection of cathodic and anodic current is lower than the inhibited samples becauseof high corrosion rate compared to the inhibited samples. The corrosion rate of inhibited samples decreases in the increasing order of inhibitor concentration, that is morringa leafs extract while the inhibition efficiency increases in the increasing order of inhibitor concentration.

Figure 2 shows the graph of efficiency against quantity of inhibitor. The graph shows that as the amount of the inhibitor increases in the medium the efficiency also increases. This is an indication that the moringa leaf extract is an efficient inhibitor in the HCl medium and increased concentration will make it most efficient.

Calculation ofthe corrosion efficiency of 1g of inhibitor

$$\boldsymbol{\eta} = (1 - \frac{C_{Ri}}{C_R}) \times 100$$

$$\boldsymbol{\eta} = (1 - \frac{\mathbf{0.71811}}{\mathbf{7.8595}}) \times 100$$

$$\boldsymbol{\eta} = (1 - 0.09137) \times 100$$

$$\boldsymbol{\eta} = 90.86\%$$

The corrosion efficiency for each quantity of moringa extract was calculated using equation 2 and the corrossion efficiencies for 2g, 3g, 4g and 5g are as follows 90.86%, 93.11%, 94.99%, 95.62% and 96.54% respectively. It shows that inhibition efficiency of morringa leaf extract increases with increase in concentration in Hcl solution.

Conclusion

The comparative study of the inhibition efficiency of moringa leaf extract in 1M HClsolution using electrochemical methodclearly revealed that inboth electrochemical and weight loss methods,morringa leaves extract is a good corrosion inhibitor. The corrosion rates of mild steel in hydrogen chloride (HCl) solution decreases gradually with increase in concentration of the inhibitor and the calculated efficiencies increased with increased concentration. Thus,morringa leafextract as inhibitors is recommended in the industries to mitigate against corrosion of mild steel in order to enhance the functionality, durability and efficiency of mild steel component.

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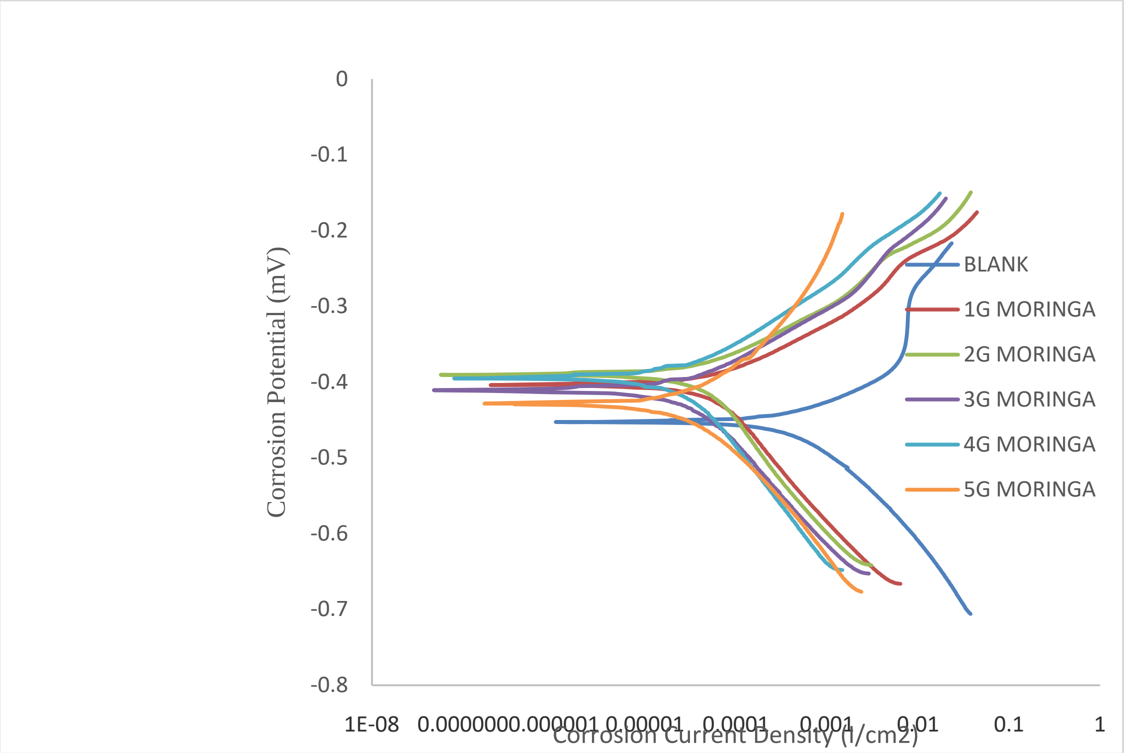

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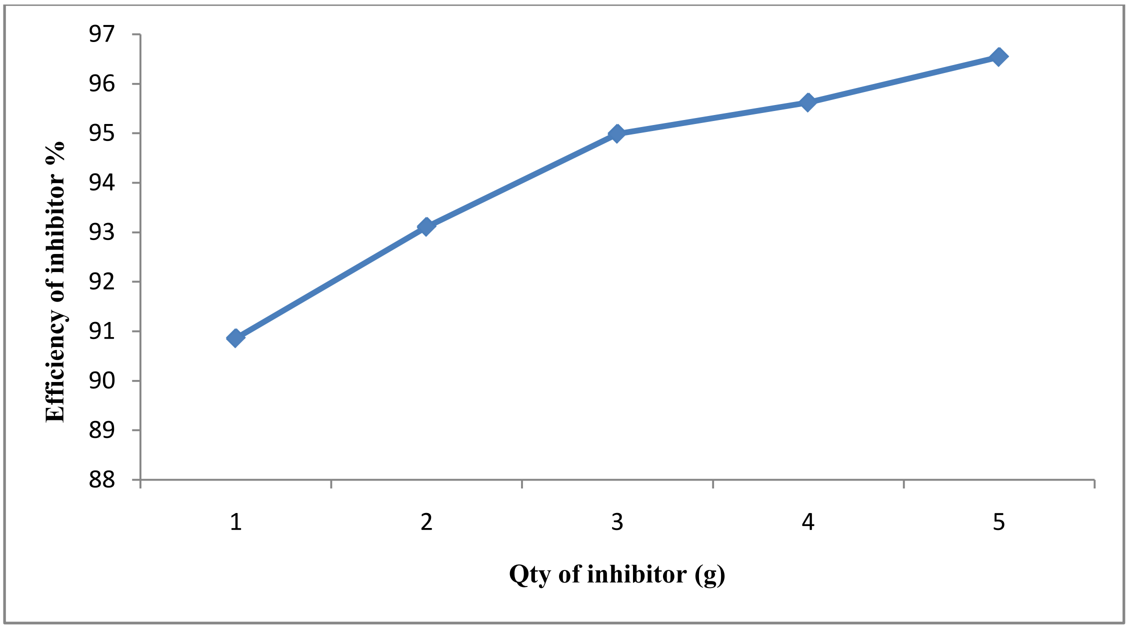

Fig. 2 graph of efficiency against the amount of inhibitor in grams