

## Original Research Article

# Investigation into the Effects of Grape Fruit Extract on the Corrosion of Mild Steel

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**Abstract:** Metals generally deteriorate with chemical attacks and reaction with environments. This paper investigates the effect of grape fruit extract on the corrosion of mild steel using weight loss and thermometric measurements. The concentration of the inhibitors used was varied from 0.1g/s to 0.5g/s in acidic medium. Standard concentrated HCl acid with density of 1.18g/cm<sup>3</sup> and a percentage purity of 35% with a molar mass of 35.5g was used. The results shows that the corrosion rates obtained decreased with addition of different of concentrations of inhibitor with the lowest values were obtained at addition of highest concentration (0.5 g/l) of the studied extract. It could be observed that the temperature fluctuates with time and reach the peak at approximately 360 min and then decreased. The reason for this can be attributed to increase in blocking of free movement of corrosion product (Fe<sup>2+</sup>) by the adsorption of the inhibitor, thereby reducing the creation of more ions and its precipitates with increase in time. The weight loss of mild steel increased as the exposure time increases in the absence and presence of inhibitor. The higher the concentration of inhibition, the lower the corrosion rate and grape fruit juice is a good inhibitor of corrosion.

**Keywords:** Metals, environments, thermometric measurements, HCl acid.

## 1.0 INTRODUCTION

Corrosion is an ever present and unceasing problem, often hard to eradicate totally. Deterrence would be more realistic and attainable rather than absolute elimination. Corrosion may also be considered as a redox process in which an oxide coating is formed on the surface of the metal/alloy undergoing the process. The pattern of attack is largely governed by the combined influences of several factors relating to metal or alloy, condition of service and the chemical nature of the environment.

These processes however, require the use of corrosion inhibitor in order to reduce acid damage on metallic materials. In the chemical, oil, gas, automobile and transportation industries metallic degradation is one of the main factors influencing the dependability of the systems (Koch *et al.*, 2002). For instance in oil, gas and petrochemical concerns thousands of kilometres of pipeline, pumps, pressure and storage vessels are used to process, store and transport products. These infrastructures are not only critical to the survival of these industries but also indirectly to the economy of the nation. However, because a large majority of these installations with their components are made of carbon steel and aluminium alloys they are inevitably susceptible to corrosion or degradation.

In metals, mechanical, physical and chemical properties must be considered. According to Shreir and Jarman [2], the mechanical and physical properties may be expressed in terms of constants, while the chemical properties of a given metal are dependent entirely on the environmental conditions prevailing during service. While a metal or an alloy may be chosen largely on the basis of its mechanical and physical properties, the fact still remains that there are very few applications involving the effect of the interaction of a metal with its environment that can be completely ignored. The importance of this interaction is of varying significance depending on the circumstance. For instance, the slow uniform

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wastage of steel of massive cross section (as in railway lines or sleepers) is not far less important than the rapid perforation of buried steel pipe or the sudden component in sodium hydroxide solution.

However, corrosion of metals generally increases with increasing acid concentration and temperature. This has been attributed to the fact that reaction rates increase with increase in temperature and concentration. It has however, been observed by Ebenso *et al.*, [3] that, when an inhibitor is introduced into a system, corrosion rates decrease while inhibition efficiency increase with increasing inhibitor concentration and decreasing temperature [1]. This, according to these workers, is due to physical adsorption. In some situations, inhibition may be via chemical absorption where corrosion rates decrease with increase in temperature. Increase in temperature and concentration of the inhibitor often lead to an increase in the rate of diffusion and ionization of active species in the corrosion process. It has however, been reported by some authors [4] that, above certain critical concentrations, the compounds used act as accelerators instead of inhibitor. Imidazoline and its precursor amide according to Oguzie *et al.*, [5], are very effective inhibitor intermediates and are widely used in formulating the corrosion products for application in the oil and gas industries. Their high temperature corrosion inhibition performance was evaluated and compared. From this evaluation, Chen [6] showed that imidazoline and amide offer poor performance respectively at moderately high temperature of 60°C with the amide giving a better thermal stability. Both gave excellent, comparable inhibition performance at a moderate temperature of 35°C. These chemistries, according to Chen [6], can provide up to 90% effectiveness at high temperature, if the inhibitor concentration is very high.

## 2.0 MATERIALS AND METHOD

### 2.1 Work Materials and Specimen's Preparation

The investigation is aim at studying the effects of grape fruit extract on the corrosion of mild steel. Table 1 shows the percentage chemical composition of the mild steel test specimen used for the study. The sample was machined into 2.0 x 0.2 x 2.5cm dimension coupon test samples and descaled by wire brushing. They were grinded using different grade of abrasive grinding paper from grit 60 up to grit 120 to ensure a smooth surface and hence, reduce corrosion attack on the samples.

**Table 1: Chemical composition of the mild steel sample**

Element	C	Si	Al	Ca	Mn	Fe	Cu	Cr
Composition %	0.05	0.13	0.20	0.10	0.49	97.76	0.07	0.03

The mild steel samples were then carefully cleaned with distilled water, degreased with ethanol, dipped into acetone, dried in air and kept in an air tight container until the period of usage to reduce risk of corrosion.

### 2.2 Preparation of Inhibitor (Grape fruit juice)

The grape fruit juice was collected at Ado-Ekiti, Ekiti State, Nigeria. The juice was squeezed out of the grape fruit into an air tight container.

### 2.3 Preparation of Test Solution

Standard concentrated HCl acid with density of 1.18g/cm<sup>3</sup> and a percentage purity of 35% with a molar mass of 35.5g was used in the experiment. The concentrated HCL was diluted in 500cm<sup>3</sup> of distil water to get 2molar solution of HCL. The inhibitor of 0.1 to 0.5g/l was accurately weighted and dissolves in the prepared 2M HCL solution in different 250ml capacity beaker to obtain different inhibitor concentration.

### 2.4 Weight Loss Measurement

The welded mild steel coupon samples were weighed and then completely immersed in the prepared solutions in the beakers in the absence and presence of the studied inhibitor in concentration at room temperature, which was maintained in a thermostated water bath. At every 3 hours exposure time, the welded mild steel coupons was removed, washed thoroughly to remove the corrosion product with emery paper, rinsed with distilled water and acetone and dried in air. Each corroded coupon was then reweighed and recorded to determine the weight loss, corrosion rate and inhibition efficiency. The experiment was run progressively for 18 hours.

The difference between the initial weight,  $W_b$ , and the final weight,  $W_a$ , of each coupon were found for each concentration of the Grape fruit juice extract in the prepared acid solution and was recorded as the weight loss  $W_g$ , the corrosion rate, CR (g/cm<sup>2</sup>h), and the inhibition efficiency IE% were calculated using Eqs 1 and 2, respectively (Stephen and Adebayo, 2018).

$$CR = W / At \dots\dots\dots Eqn (1)$$

Where A is the area of the sample (cm<sup>2</sup>) and t is the immersed time in hours

$$IE\% = ((Cr_a - CR_p) / CR_a) \times 100 \dots\dots\dots Eqn (2)$$

Where  $CR_a$  is the corrosion rate of sample in the absence of inhibitor and  $CR_p$  is the corrosion rate of sample in the presence of inhibitor.

The surface coverage,  $\theta$ , which can be defined as the maximum (saturation) surface occupied of the inhibitor on a given available absorption surface, is division of inhibitor efficiency (IE%) by 100. Thus, for different concentration of inhibitor from weight loss measurement, it is expressed as;

$$\theta = (CR_a - CR_p) / CR_a$$

Where  $CR_a$  and  $CR_p$  are as previously defined Stephen and Adebayo [9].



Figure 1: Experimental set up of weight loss measurement

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Results

##### 3.1.1 Weight Loss Measurement

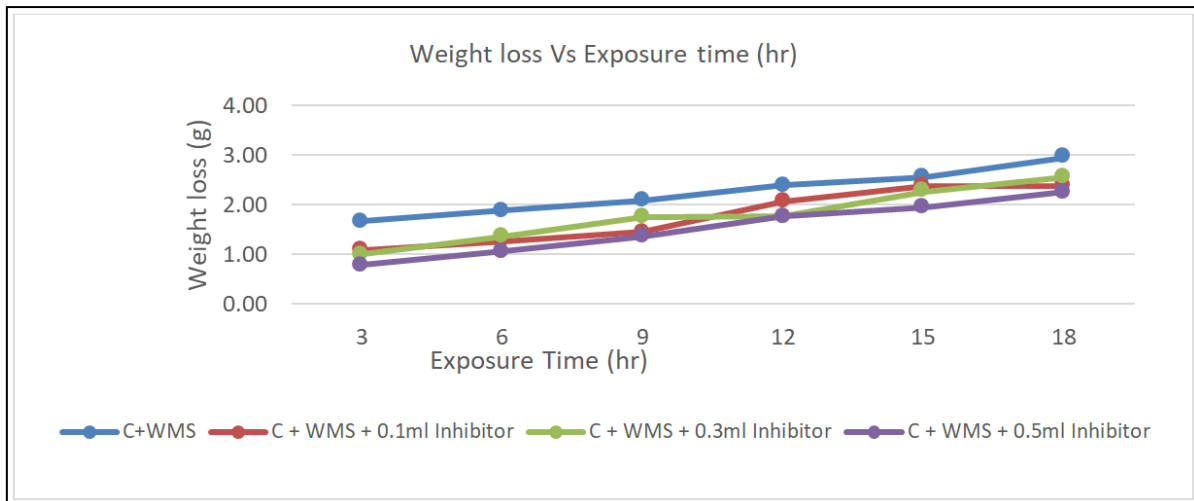
The weight loss method in corrosion is the simplest and longest-established technique to calculate the corrosion rate. It involves the exposure of a clean weighed piece of the metal (welded mild steel as used in this study) or alloy to the corrosive environment for a specified time followed by cleaning to remove corrosion products and weighing the piece to determine the loss of weight. Table 2 and 3 showed the Weight loss vs exposure time of concentrated HCl solution and weight loss vs exposure time of diluted HCl solution.

Table 2: Weight loss vs exposure time of concentrated HCl solution

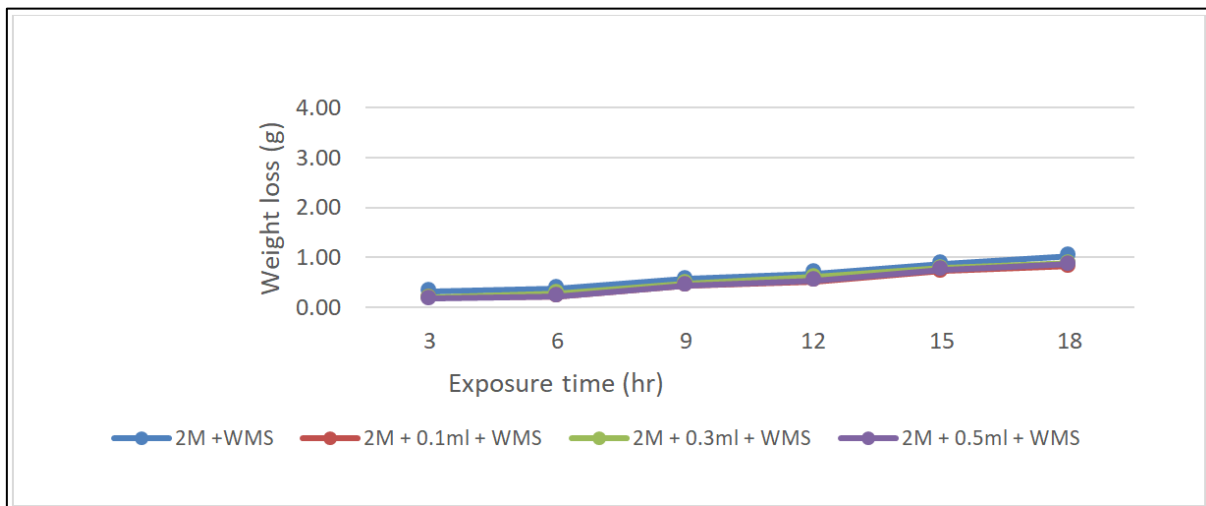
Inhibitor/Conc (g/l)	Exposure Time (hour)					
	3	6	9	12	15	18
C+WMS	1.6773	1.8928	2.09295	2.3883	2.5558	2.9481
C + WMS + 0.1ml Inhibitor	1.0763	1.2618	1.4525	2.0566	2.3731	2.3721
C + WMS + 0.3ml Inhibitor	0.9999	1.3569	1.7567	1.7608	2.2686	2.5611
C + WMS + 0.5ml Inhibitor	0.7802	1.0549	1.349	1.7618	1.9437	2.2592

Table 3: Weight loss vs exposure time of diluted HCl solution

Inhibitor/Conc (g/l)	Exposure Time (hour)					
	3	6	9	12	15	18
2M +WMS	0.3111	0.3831	0.5774	0.6825	0.8813	1.0234
2M + 0.1ml + WMS	0.1958	0.2240	0.4364	0.5250	0.7401	0.8239
2M + 0.3ml + WMS	0.2089	0.2824	0.4841	0.6064	0.7927	0.8854
2M + 0.5ml + WMS	0.1783	0.2212	0.4391	0.5307	0.7518	0.8640



**Figure 2: Graph of weight loss Vs exposure time for concentrated HCL solution**



**Figure 3: Graph of weight loss Vs exposure time for diluted HCL solution**

In the weight loss vs exposure time of concentrated HCl solution (Figure 2), there is a significant different in the weight loss of the samples when compared with Figure 3 which shows for diluted HCl solution.

### 3.1.2 Corrosion Rate

Table 4 showing corrosion rate of diluted HCl solution while Table 5 showed the corrosion of concentrated HCl solution.

**Table 4: Corrosion rate for diluted HCL solution**

Inhibitor/Conc (g/l)	CR
2M + 0.1ml + WMS	0.041
2M + 0.3ml + WMS	0.0409
2M + 0.5ml + WMS	0.0406

**Table 5: Corrosion rate for concentrated HCL solution**

Inhibitor/Conc (g/l)	CR
C + WMS + 0.1ml Inhibitor	0.01577
C + WMS + 0.3ml Inhibitor	0.01476
C + WMS + 0.5ml Inhibitor	0.01395

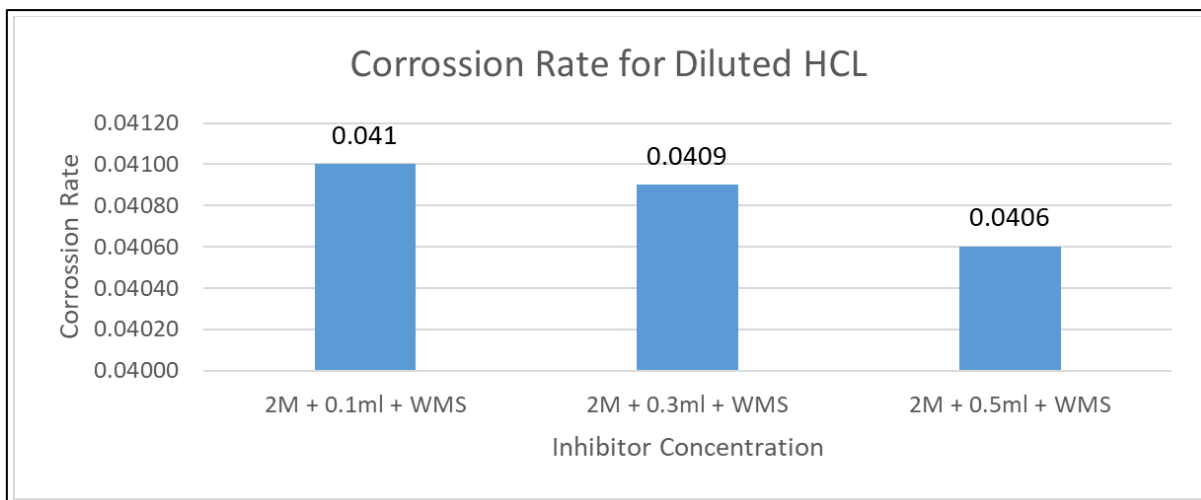


Figure 4: The graph of Corrosion rate for diluted HCL solution

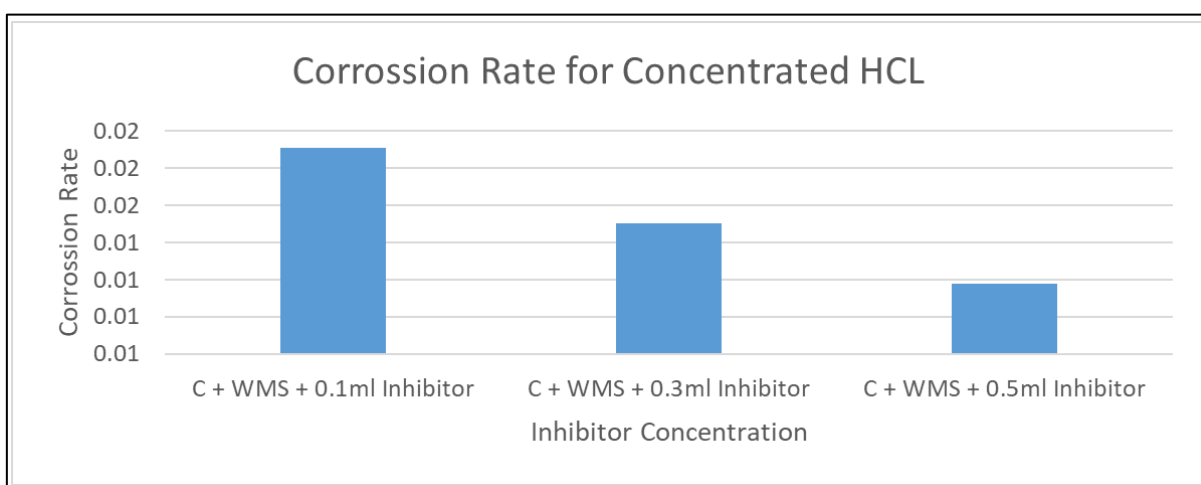


Figure 5: Corrosion rate for concentrated HCL solution

Figure 4 determination of corrosion rate for diluted HCl solution while Figure 5 shows the corrosion rate for concentrated HCl solution. The various corrosion rates obtained decreased with addition of different of concentrations of inhibitor and lowest values were obtained at addition of highest concentration (0.5 g/l) of the studied extract.

### 3.1.3 Inhibitor Efficiency

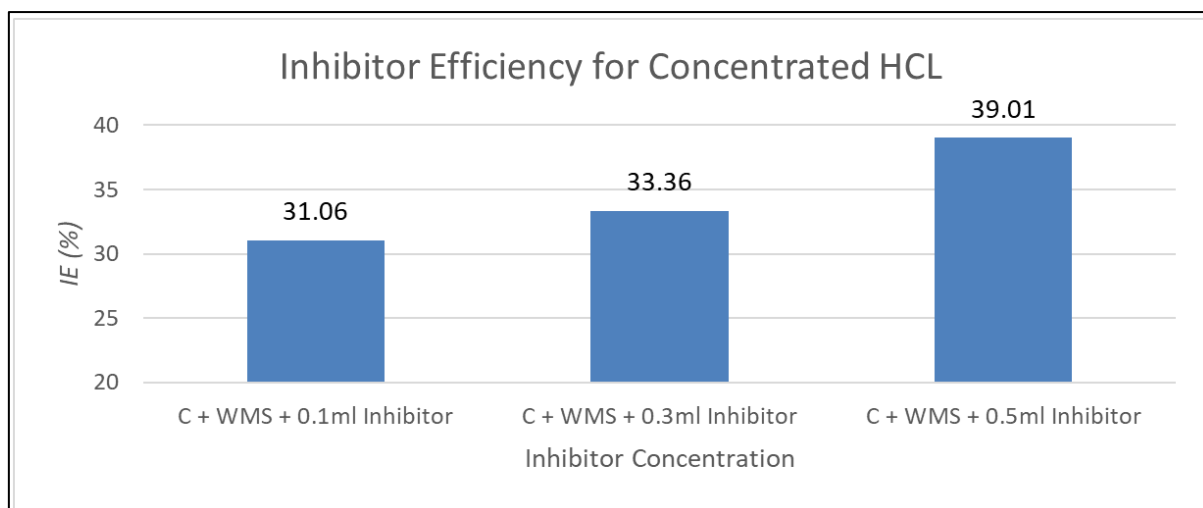
Table 6 shows inhibition rate for concentrated HCl solution while Table 7 illustrates the inhibition rate for diluted HCl solution.

Table 6: Inhibitor efficiency for concentrated HCL solution

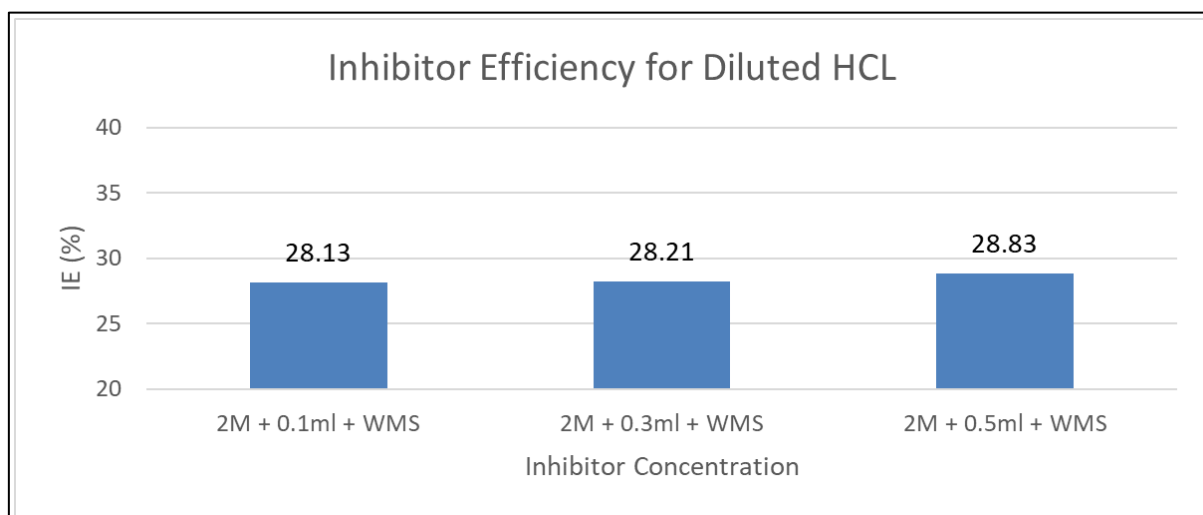
Inhibitor/Conc (g/l)	IE (%)
C + WMS + 0.1ml Inhibitor	31.06
C + WMS + 0.3ml Inhibitor	33.36
C + WMS + 0.5ml Inhibitor	39.01

Table 7: Inhibitor efficiency for diluted HCL solution

Inhibitor/Conc (g/l)	IE (%)
2M + 0.1ml + WMS	28.13
2M + 0.3ml + WMS	28.21
2M + 0.5ml + WMS	28.83



**Figure 6: The graph of Inhibitor efficiency for concentrated HCL solution**



**Figure 7: The graph of Inhibitor efficiency for diluted HCL solution**

Figure 6 illustrate the inhibition rate for Concentrated HCl solution and Figure 7 illustrates the inhibition rate with diluted HCl solution. It was observed in Figures 6 and 7 that the inhibition efficiency of both the diluted HCl and concentrated HCl coverage increases with increase in inhibitors concentrations. However, the increase in the diluted group is not as high as that of the concentrated group. Some non-uniformity of inhibition efficiency values was a result of dimeric film formed on the surface of the steel as suggested by Noor [8].

#### 4.0 CONCLUSION

The corrosion inhibition strength of studied grape fruit juice extract (Inhibitor) on welded mild steel in 2M HCl was examined using weight loss and thermometric measurements. The inhibitor showed excellent inhibition efficiency on welded mild steel corrosion in HCl solution, its inhibition efficiency increases in concentration of inhibitor as 28.83 % and 39.01 % were obtained. However, weight loss of mild steel increased as the exposure time increases in the absence and presence of inhibitor and the higher the concentration of inhibition, the lower the corrosion rate.

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