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Evaluation of Expired Augmentine Drugs as Corrosion Inhiitor for Carbon Steel Alloy in 1.0 n hcl Acidic Environment Using Analytical Techniques

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Abstract

*Augmentin is a chemical mixture component medicine (co medicine) known as co-amoxiclav and it is a famous antibiotic used for treatment of a number of bacterial infections, it is so dangerous to be left in the environment after its expired as it is harmful to the child's, so the present work introduces an idea for using it in the expired form as green corrosion inhibitor for steel in 1.0 N HCl. Five analytical techniques were used to evaluate the inhibition performance of the expired co-amoiclav drugs namely gravimetric, atomic absorption spectroscopy(AAS), thermometric, gasometric, and acidimetric technique. Effect of expired drug dose, reaction temperature, and **pH** were studied. The corrosion inhibition was found to increase by increasing concentration and decreased with rising the temperature and by lowering **pH**.* The maximum inhibition is (96.5 % at 300 ppm. *The used techniques are in good agreement to each other's (±2 %) indicating the possibility of the using of the expired Augmentin drugs as potential nontoxic green corrosion inhibitor for steel in an industrial field like steel used for application in petroleum industry at lower **pH**.*

Keywords: *Expired drugs; Green inhibitors, Gravimetric; Thermometric; AAS; Acidimetric.*

1. Introduction

Augmentin is a chemical mixture consists of of Amoxicillin and potassium salt of clavulanic acid, also known as co-amoxiclav, is an antibiotic useful for the treatment of a number of bacterial infections. co-amoxiclav is one from the famous antibiotic used for treatment of a number of bacterial infections, it is highly spread in our homes, so it is so dangerous to be left in the environment after its expired as it is harmful to the child's. generally, drugs are one of the most famous chemical materials of every daily and continuous use in our homes, the expired drugs considered as the dangerous materials in the environment cause the death of more than 2000 child's every year, in some countries the expired drugs were wasted in the holes in a deserts which leading to the pollution of the underground water by harmful materials. All this observations take the attentions of Reda Abdel Hameed to search about the new applications for the expired drugs, the use of expired drugs as corrosion inhibitors for metals was introduced by Reda Abdel Hameed 2009 and 2011, [1,2] when he used the expire ranitidine drugs as eco-friendly potential nontoxic corrosion inhibitor for aluminum in hydrochloric acid solution, his work have been take the attention of another scientists to investigate many expired drugs as corrosion inhibitors, Further, the research of unused drugs has been focused on corrosion inhibition of carbon steel in various aggressive media[3-7]. In the last decade the scientific efforts in the field of corrosion inhibition were attended on the eco-friendly and potential nontoxic corrosion inhibitors known as green corrosion inhibitors. The most recent efforts are the use of expired drugs to solve not only the problem of solid waste accumulations but also to introduce a potential non-toxic inhibitor also to save energy, money consumed in the preparing or sailing a chemical corrosion inhibitor as about of 7 % from the total income were consumed in the corrosion inhibition of metals and alloys in industrial fields [8-12]. The corrosion performance of carbon steel after

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wide-ranging acquaintance load of aqueous extract of Lawsonia inermis as a green inhibitor in saline media was studied [40] using chemical and electrochemical techniques In addition, the scanning electron microscopy (SEM) and energy-dispersive X-ray (EDX) analysis stayed applied as a complementary tool for surface characterization [40, 41]. Some Ionic Liquid as Water Soluble and Potential nontoxic Inhibitor for Corrosion and Microbial Corrosion for Iron Artifacts was studied by M. El-Shamy et al [41-42]. From the green chemistry point of view, the application of the expired drugs materials as inhibitors help in: 1) avoid the toxic effect of some toxic inhibitors to human, 2) using drugs save the energy and organic solvent used in the synthesis of the corrosion inhibitors 3) there is no any waste materials during the using of the drugs as inhibitors, in addition 4) avoid the accumulation of drugs waste which is dangerous on the child's and ground water, so the expired drugs considered as green inhibitors, because There is no any waste for the process of using drugs as inhibitors as it was taken directly from the drug market to the laboratory, where they are used in their pharmacological form which is safe for humans and the environment in very few doses. In addition, the Corrosion is the process of oxidation of metals by its environment, leading to corrosion products and the destruction of the metal lattice this phenomenon represents: a terrible waste of both natural resources and money. So that the corrosion control of steel is of technical, economical, and environmental importance, when steel was corroded changed from hard and useful metal into corrosive product which is hazard to the environment so the corrosion control of steel considered as green process, also The damage by corrosion results in highly cost for maintenance and protection of materials used. Finally, the expired drugs considered as green inhibitor as it is a nontoxic inhibitor to human specially at very low concentrations, in addition, prevention of the steel from corrosion is of environmental importance, as corrosion a terrible waste of both natural resources and money. In the previous works [13,14] expired paracetamol and expired Indomethacin were used as corrosion inhibitors for steel in acidic and sodium chloride corrosive environment using chemical and electrochemical techniques. Analytical and electroanalytical are highly effective and widely used for evaluation of large numbers of materials as corrosion inhibitors for metals and alloys in many different aqueous corrosive environment, containing acids, alkaline, and aqueous salts [15-30]. In the present work five different analytical techniques were used to evaluate the expired Augmentin drugs as green corrosion inhibitor for steel alloy in 1.0 N hydrochloric acid corrosive environment, effect of expired drugs concentrations, reaction temperature, and pH on the corrosion inhibition efficiency were studied. The survey of the literature shows that the Augmentin is a chemical mixture of Amoxicillin and potassium salt of clavulanic acid, also known as co-amoxiclav, is an antibiotic useful for the treatment of a number of bacterial infections. It is a combination consisting of amoxicillin, a β-lactam antibiotic, and potassium clavulanate, a β-lactamase inhibitor. It is specifically used for otitis media, strep throat, pneumonia, cellulitis, urinary tract infections, and animal bites. It is taken by mouth or by injection into a vein. Many branded products indicate their strengths as the quantity of amoxicillin. Augmentin 250, for example, contains 250 mg of amoxicillin and 125 mg potassium salt of clavulanic acid [31-32]. . From the literature we can concluded that the expired Augmentin drugs is highly promise as corrosion inhibitors for steel in acidic environment. and promise for the application in many industrial fields like steel used in the manufacturer of the tanks, boilers, and petroleum pipe lines.

2. Experimental

2.1. Materials and Test Solution

The corrosive solution prepared in this study is aggressive 1.0 N hydrochloric acid of 0.0 pH, which prepared from analytical grade 37% HCl (Sigma Aldrich) prepared by dilution with double-distilled water and titrated against 1.0 N Na_2CO_3, then diluted to appropriate required pH. Each experiment is performed in aerated stagnant solutions and was repeated at least three times under the same conditions to check the reproducibility and the average of the three replicated values was used for further processing of the data. The gravimetric composition of steel materials employed in this study is given in table 1. It is similar to the composition the carbon steel used in manufacturer of petroleum pipe lines. Augmentin drug is taken from our home as a product of Glaxo Smith Kline (GSK) company, UK, was used as inhibitor in the form of tablets after expired date by 6 months. It is used as green corrosion inhibitor for steel in the present study and its chemical structure and composition are given in figure 1.

2.2. Gravimetric studies

The corrosive solution prepared in this study is aggressive 1.0 N hydrochloric acid of 0.0 pH, which prepared from analytical grade 37% HCl (Sigma Aldrich) prepared by dilution with double-distilled water and titrated against 1.0 N Na_2CO_3, then diluted to appropriate required pH. Each experiment is performed in aerated stagnant solutions and was repeated at least three times under the same conditions to check the reproducibility and the average of the three replicated values was used for further processing of the data. The gravimetric composition of steel materials employed in this study is given in **table 1**. It is similar to the composition the carbon steel used in manufacturer of petroleum pipelines.

Augmentin drug is taken from our home as a product of Glaxo Smith Kline (GSK) Company, UK, was used as inhibitor in the form of tablets after expired date by 6 months. It was used as green corrosion inhibitor for steel in the present study and its chemical structure and composition are given in figure 1.

2.2.1. Weight Loss measurement

The technique is based on determining the weight loss (WL) of a sample (coupon) of the surface (S) immersed for a time (t) in the aggressive solution. The tests are performed in 100 ml glass vials in non-aerated medium, at room temperature. The immersion time is 8 h, the iron samples are undergoing cleaning with distilled water, degreasing with acetone and drying before and after the immersion. The determination of the corrosion rate W was made from the following relation (1):

$$W = \frac{mi - mf}{St} \qquad (1)$$

where W ($mg.cm^{-2}.h^{-1}$) is the corrosion rate, m_i (mg) and m_f (mg) are the mass before and after exposure to test solution, respectively, S (cm^2): is the surface of area of specimen, t (h): is the immersion time. Regarding the inhibitory efficiency I.E.% and the surface coverage (θ), which represents the part of the metal surface covered by the inhibitors molecules, were calculated according to the following equations:

$$\% I.E = ([W^O - W] / W^O) \times 100 \qquad (2)$$

$$\theta = ([W^O - W] / W^O) \qquad (3)$$

where W^o and W represent the corrosion rates in the absence and presence of the inhibitors, respectively.

2.2.2. Atomic absorption Spectroscopy (AAS) measurements

Quantification of iron ions contents in corrosive solutions in the absence and presence of the used drugs as corrosion inhibitors are determined by atomic absorption spectroscopy(AAS). Concentration of the ferric ions passed into solution have been performed by using Varian Spectra AA 220 atomic absorption spectroscopy. In order to determine the concentrations of iron ions within corrosive solution both when the inhibitor was absent and present, we dissolved the corrosive medium by aqua regia [13].

2.3. Gasometrical Measurements (Hydrogen Evolution Measurements)

The progress of the corrosion reaction are determined by volumetric measurement of the evolved hydrogen. The metal sample was put in a Büchner flask containing the test solution. The flask is sealed with a rubber bung, and from its hose barb protruding from its neck, rubber tubing is connected to the bottom of an inverted measuring cylinder, which is fitted above a basin. The cylinder and the basin are filled with distilled water. The evolved hydrogen gradually displaces the distilled water and was collected at the top inside the cylinder, and its volume is measured directly with time [17]. The experiments are done in the absence and presence of different concentrations of the tested inhibitor.

2.4. Thermometric measurements

The carbon steel sheet was press cut 2 x2 x 0..1 cm with chemical composition as aluminium foil. mentioned in table 1. The measurements were carried out in a Dolvacpyrex flask cover with sheet of The reaction vessel consists of 50 ml of the acid test solution put into the flask covered with sheets of aluminum foil, corked with a Check temp digital thermometer in place. The metal coupon was introduced into the corrosive solution and quickly covered. Thermometric measurements depend on measuring the temperature variation during the reaction of a metal with test piece with a definite volume of a corroding solution [13,17]. The variation of temperature of the system was monitored with time and the reaction number (RN) is defined as [13,17]

$$RN\ (^0C/min.) = (T_m - T_i) / t_m \qquad (4)$$

Where T_m and T_i are the maximum and initial temperature respectively, t_m is the time in minutes taken to attain the maximum temperature.

2.5. Acidimetric Measurements

Each experiments were preceded by evaluation for the pH of the prepared solution by a standard BT-500 model pH meter (Germany). The pH was checked for the five concentrations 50, 100, 150, 200,250, and 300-ppm pre and post dipping in the checked solution for 5 hrs. The %IE computed by implementing in the next equation.

$$\% I.E = 1\ ([\Delta H^+]_{inh} / [\Delta H^+]_{uninhi}) \times 100 \qquad (5)$$

Where ΔH^+ inh. and ΔH^+ uninhi. are changes in H^+ concentration with and without of the inhibitor, respectively [33].

3. Results and discussion

Simple analytical techniques were used in estimation of the corrosion rate and ferrous ion determination in the presence and absence of Augmentin drugs as green corrosion inhibitors in acidic environment of 1.0 N HCl solution.

Element	Mn	Si	S	P	C	Fe
Composition Weight (%)	0.517	0.201	0.009	0.007	0.157	About 99 %

Table 1. Gravimetric composition of the used steel materials

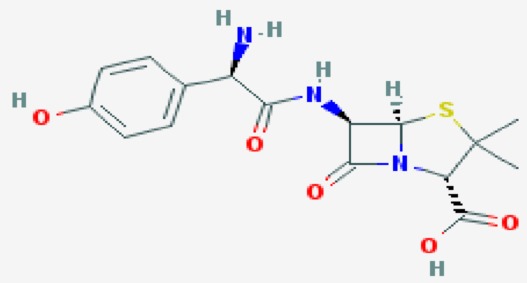
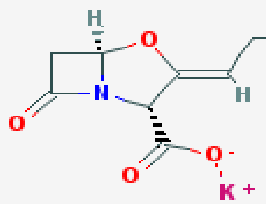
Drug constituent name	% composition	Drug chemical structure
Amoxicillin	250 mlligram	
Potassium salt of Clavulanic acid	125 milligram	

Fig. 1. Structure and composition of Augmentin Drugs (co-amoxiclav)

In the present research effect of inhibitor concentration, pH, and temperatures were studied, different techniques were also used in this study are, gravimetric, thermometric, gasometrical, acidimetric, and atomic absorption spectroscopy (AAS) as analytical techniques. The used Augmentin drugs as green inhibitor is symbolized here as AUG. The studied concentrations are 50,100,150,200, 250 and 300 ppm. The used expired drugs used in the present study as safe and green corrosion inhibitor for steel is promise for future application towards the carbon steel alloys used in heavy industries including boilers, water tanks, and petroleum pipe lines.

3.1 Gravimetric Measurements

3.1.1. Effect of Concentrations

Gravimetric techniques were used in determination of the corrosion rate and corrosion inhibition efficiency %I.E of expired Augmentin drugs for the various concentrations of AUG inhibitor after 7 hours of immersion of steel coupon in hydrochloric acid corrosive environment of different pH (pH 1,2, and 3). The values of corrosion rate (W) and corrosion inhibition efficiency %I.E are given in **table 2.** And **figures 2.** According to gravimetric results the weight loss and consequently the corrosion rate decreases and inhibition efficiency increases by adding the expired Augmentin drugs (AUG) green inhibitor and this behavior was increased by increasing the AUG inhibitor concentrations. It's clear that the inhibition efficiency increase as the inhibitor concentration increases to attain 98 % at 300 ppm. The inhibitory efficiency % I.E and the surface coverage (θ), which represents the part of the metal surface covered by the inhibitors molecules, were calculated according to **equations 2 and 3** mentioned in experimental part. Inspection of **table 2** reveals that; the values of inhibition efficiency increase with increasing concentration of drug and decreased by lowering pH of the medium. **Figure 2** reveals that by increasing the concentrations of expired AUG drugs, the weight loss of carbon steel samples are reduced this clarified that the occurrence of these compounds lowered the dissolution of iron in 1.0 N HCl solution indicating that these drugs act as inhibitors. The relation between weight loss with time in uninhibited and inhibited 1.0 N HCl is linear, this illustrates that the absence of insoluble surface films during corrosion. In this case, the inhibitors are firstly adsorbed onto the metal surface and thereafter impede corrosion either by merely blocking the reaction sites (anodic and cathodic) or by altering the mechanism of the anodic and cathodic partial processes, **[32]**. The maximum inhibition efficiency obtained using 300 ppm of expired Augmentin drugs is 98% which is higher when it compared by the obtained efficiency in the cited references (previous works) **[13,14]**. this observation may be due to the presence small amount of potassium iodide as additives in the augmenting drugs which act as promoter for organic drugs molecule, as mentioned elsewhere **[13,26]** the presence of inorganic salts has synergistic effect on the corrosion inhibition efficiency.

Table 2. Effect of increasing concentration of the AUG drugs on the corrosion parameters of steel in HCl solution of different pH obtained from the weight loss measurements at 303 k.

	pH = 1			pH = 2			pH = 3		
Expired drugs Concentrations ppm	**W mg cm^{-2} hr^{-1}**	**I.E. %**	**θ**	**W mg cm^{-2} hr^{-1}**	**I.E. %**	**θ**	**W mg cm^{-2} hr^{-1}**	**I.E. %**	**θ**
Blank	9.00	-	-	7.8	-	-	6.9	-	-
50	0.95	89.4	0.894	0.84	89.7	0.897	0.56	91.9	0.919
100	0.88	90	0.9	0.71	91	0.91	0.42	93.9	0.939
150	0.89	90.2	0.902	0.56	93.5	0.935	0.31	95.5	0.955
200	0.75	91.7	0.917	0.47	94.5	0.945	0.28	95.9	0.959
250	0.6	93.3	0.933	0.39	95	0.95	0.23	96.7	0.967
300	0.5	94.4	0.944	0.27	96.5	0.965	0.15	97.8	0.978

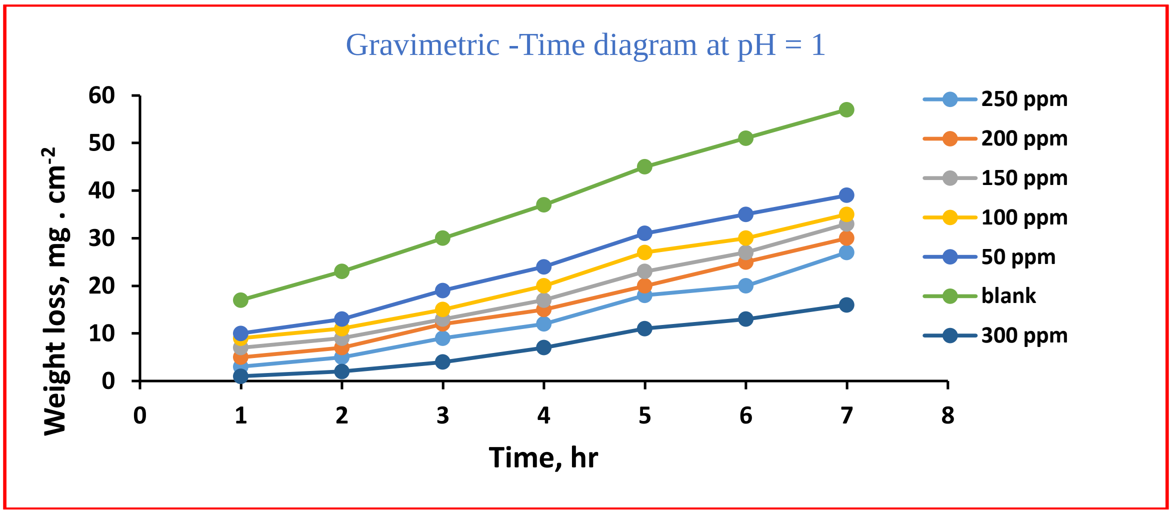


Figure 2. Weight loss of steel as a function in time in 1.0 N HCl in absence and presence of expired AUG drugs as green inhibitor for steel corrosion.

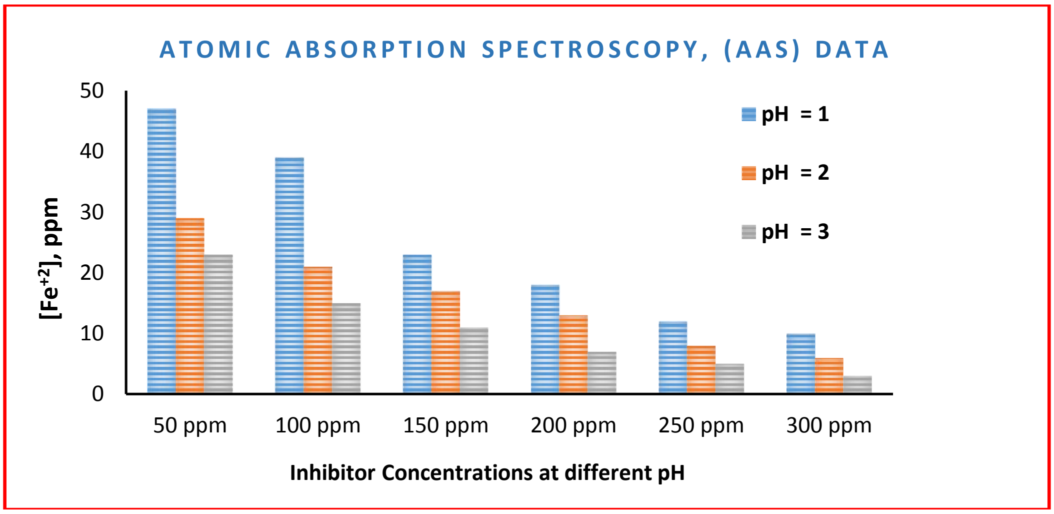
3.1.2. Effect of temperature

To elucidate the mechanism of the inhibition process and to determine the kinetic parameters of the corrosion process gravimetric (weight loss) measurements were performed at different temperatures e.g., 303,313,323,333K. The effect of temperature on the percentage inhibition efficiency of steel in the presence of the inhibitor is graphically represented in **figure 3.** It is obvious that the values of %I.E decreased with increase in temperature, leading to the conclusion that the protective film of these compounds formed on the steel surface is less stable at higher temperature; which may be due to the desorption of some adsorbed molecules from the surface of the steel at higher temperature due to which greater area of the metal is exposed to the acidic environment **[36-39].** All the experiments were done three times and the recorded data was taken to the medium value with (± 0.1) error.

3. 2. Atomic Absorption Spectroscopy(AAS)

Atomic absorption spectroscopy (AAS) produce considerable simplification of procedures for the analysis of aqueous, acidic, or basic solutions, and thereby contribute to a reduction in costs. The industrial application of atomic absorption for routine analysis it was divided into four areas: (1) the incoming inspection of all raw materials, (2) production testing, (3) final inspection of all products, and (4) environmental analysis. For rapid analysis during the production process atomic absorption is mainly of indirect value because, as the sequential character of the technique, it cannot be used for complete steel or slag analysis in a two to three-minute period **[13,35].** AAS techniques were used for corrosion rate prediction in different media, acidic, basic, and neutral based on fundamental chemistry of the solubility of the corrosion products. The AAS method was applied to the determination of Fe ions in mineral waters and natural waters **[13,35].**

Figure 3. Effect of temperature on % I.E for steel in 1.0 N HCl in the presence of different concentrations of the expired AUG drugs as green inhibitor, data from weight loss at pH = 3



The iron ions released into solution due to corrosion were detected directly by atomic absorption spectroscopy and their concentration was determined using a calibration curve. The corrosion of the iron samples in solution was accelerated by high salinity, lowering pH, the presence of chloride ions, and temperatures **[13]**. Iron corrosion is a complex process that occurs when iron was exposed to oxygen and humidity and is exacerbated by the presence of chloride ions. The deterioration of iron structures or other components can be costly to society and can be evaluated by following the properties of the corroding material **[13]**. In the present study the ferrous ions Fe^{+2} concentrations result due to corrosion of steel by acidic HCl of different pH were determined by atomic absorption spectroscopy (AAS) techniques. The concentrations of the ions passed into solution has been performed by using AAS in order to determine the concentrations of ferrous ions within corrosive solution both when the green inhibitor was absent and present. The data of AAS are listed in **table 3** and **figure 4** Which shows that the ferrous ion Fe^{+2} concentrations in the corrosive medium were decreased by increasing inhibitor concentration and increased by lowering pH of the solution. Here ferrous ions concentration taken as a function of corrosion rate consequently as the ferrous ions in the solution increases the corrosion rate increases and vice versa. All process is influenced by adding inhibitor. The data in **table 3** agree well with results obtained by gravimetric (weight loss) method so that, the tow gravimetric techniques are in good agreement to each other to indicate that, the addition of expired (AUG) drugs inhibit the corrosion of steel in acidic environment and it decreases the iron dissolution process (ferrous ion concentration Fe^{+2}) in this environment at lower pH values.

3.3. Gasometrical technique (Hydrogen Evolution Method)

Gasometrical techniques based on measuring of the evolved hydrogen gas with time in the absence and presence of inhibitors in acidic environment. Gasometrical technique (hydrogen evolution method) was used for evaluation of the expired Augmentin, AUG as green corrosion inhibitors for carbon steel alloy in acidified hydrochloric acid solution of different lower pH (pH 1, 2, and 3). Iron metal is an active metal of higher oxidation potential so it replaces the hydrogen of acid easily giving metal salt and the hydrogen evolved in the form of gas.

Table 3. Effect of pH and inhibitor concentrations on ferrous ion concentrations as result of AAS technique.

Sample	**Inhibitor Concentration**	**Ferrous ion concentrations [Fe^{+2}], ppm**		
		pH = 1	**pH = 2**	**pH = 3**
Blank	Free	129	118	105
Expired Augmentin	50 ppm	47	29	23
	100 ppm	39	21	15
	150 ppm	23	17	11
	200 ppm	18	13	7
	250 ppm	12	8	5
	300 ppm	10	6	3

The volume of hydrogen evolved during the corrosion reaction of iron acidic HCl medium in the absence and presence of different concentrations of the expired AUG drugs as green inhibitor, 50, 100, 150, 200, 250, and 300 ppm. was measured with time at room temperature (30 ^{0}C). The inhibition efficiency was calculated using the following equation **[17].**

% I.E = [1- ($V_{inh.}$ / V_{free})] x 100 (6)

where, V_{inh} is the volume of hydrogen gas evolved for inhibited solution and V_{free} for the uninhibited solution. The values of evolved hydrogen volumes and inhibition efficiencies at different concentrations of the used green inhibitor, AUG, are shown in **table 4**. The inhibition efficiency increase with increasing the inhibitor concentration. which indicate that the drug inhibitor compounds act as a good inhibitor for carbon steel in HCl acidic environment.

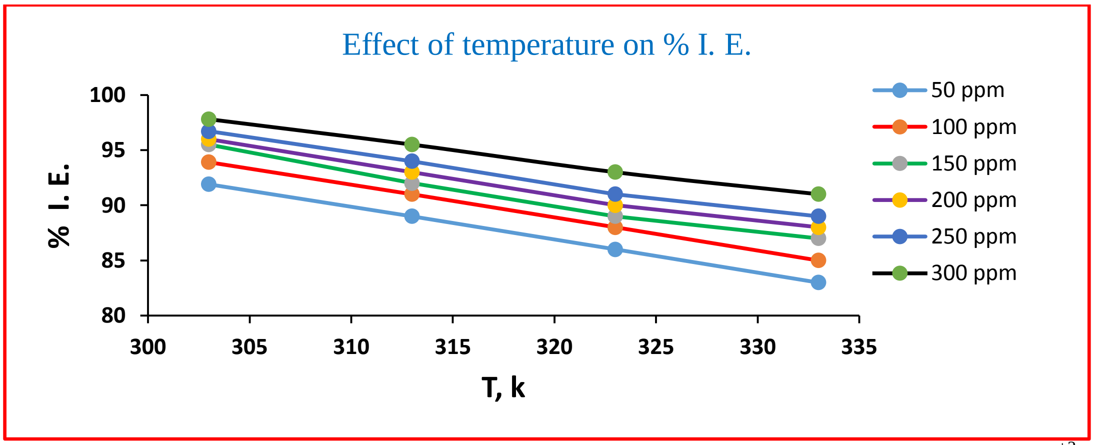


Figure 4. Effect of expired drugs(AUG) inhibitor concentrations on the ferrous ion concentration [Fe^{+2}] in the presence of 1.0 N HCl , data obtained from atomic Absorption Spectroscopy(AAS) at different pH.

Table 4. Hydrogen volumes and the percentage inhibition efficiency for the steel corrosion in acidic HCl solution of different pH with and without different concentrations of the expired AUG drug at room temperature after 7 hrs.

	pH = 1		**pH = 2**		**pH = 3**	
Expired drugs Concentrations ppm	**Volume of hydrogen (ml/ cm^2)**	**I.E %**	**Volume of hydrogen (ml/ cm^2)**	**I.E %**	**Volume of hydrogen (ml/ cm^2)**	**I.E %**
Blank	56	-	49	-	38	-
50 ppm	10	82.1	8	83.7	5	86.8
100 ppm	7	87.5	5	89.7	3.5	90.8
150 ppm	6	89.3	4	91.8	2.0	94.7
200 ppm	5	91.0	3	93.8	1.8	95.3
250 ppm	4	92.8	2	95.9	1.4	96.3
300 ppm	3	94.6	1.7	96.5	1.1	97.1

3.4. Thermometric Measurements

Reaction number (RN) values are known as a relative measure of retardation of the dissolution process **[13].** The extent of corrosion inhibition can have expressed in terms of the percentage reduction in reaction number (% RR) given by the following equation **[13].**

$$\%\mathbf{RR} = \frac{\text{RN uninhibited} - \text{RN inhibited}}{\text{RN uninhibited}} \times 100 \quad \mathbf{(7)}$$

The thermometric parameters and inhibition efficiency were summarized in **table 5.** The inhibition efficiency and t_m increase by increasing inhibitor concentrations. The inhibition efficiency and time delay (Δt_m) of the used inhibitor decrease with increasing the pH value in the following order: pH 3 > pH 2 > pH 1 . This order similar that obtained from both weight loss and gasometrical techniques.

3.5. Acidimetric measurements

The pH was checked for the five concentrations 50, 100, 150, 200,250, and 300 ppm pre and post dipping in the checked solution for 7 hrs. where [H^+], was computed in each case.

The corrosion rate (W) of steel samples was computed utilizing the next equation:

Table (5). Thermometric parameters for the steel corrosion in acidic HCl solution of different pH in presence of 300 ppm of the expired Augmentin drugs, AUG, green inhibitor.

Thermometric Parameters	**AUG** HCl of pH = 1 With expired Augmentin inhibitor	**AUG** HCl of pH = 2 With expired Augmentin inhibitor	**AUG** HCl of pH = 3 With expired Augmentin inhibitor
T_{m}, ^{0}C	41	39	36
t_{m}, min.	315	360	370
RN, ^{0}C/min.	0.035	0.025	0.016
% RR	91	93	96
Δt_{m}	293	341	362

W (mole dm^{-3} cm^{-2} h^{-1}) = **ΔH^{+} / At** **(8)**

Where [ΔH^{+}] is the variation between the first and last concentration of H^{+}, A the surface area of coupon in cm^{2} and t, the time in hrs. The %I.E was computed utilizing the next equation:

%I.E = 1- ([ΔH^{+}]$_{inh}$ / [ΔH^{+}]$_{uninh}$) x 100 **(9)**

Where ΔH^{+}_{inh} and ΔH^{+} are changes in H^{+} concentration with and without the presence of green inhibitor, AUG, respectively.

The values of surface coverage (**θ**), was computed utilizing the next equation: **[31]**

θ = 1- ([ΔH^{+}]$_{inh}$ / [ΔH^{+}]$_{uninh}$) **(10)**

As shown from the table 6 the values of corrosion inhibition efficiency and surface coverage were increased with increasing the concentration of green inhibitor AUG, due to decreasing of the hydrogen ion concentrations in the medium as inhibitor molecule act as a ligand for protons in acidic media.

Table 6 values of %I. E for acidimetric method for expired Augmentin inhibitor in 1.0 N HCl at 303K.

	pH = 1			**pH = 2**			**pH = 3**		
Expired drugs Concentrations ppm	**ΔH^{+} x 10^{4}**	**θ**	**%I.E**	**ΔH^{+} x 10^{4}**	**θ**	**%I.E**	**ΔH^{+} x 10^{4}**	**θ**	**%I.E**
Blank	96	-	-	89	-	-	82		
50	13	0.86	86	10	0.89	89	8	0.9	90
100	11	0.885	88.5	8	0.91	91	6	0.93	93
150	10	0.895	89.5	7	0.92	92	5	0.94	0.94
200	8	0.917	91.7	6	0.93	93	4	0.95	95
250	7	0.93	93	4	0.96	96	3	0.96	96
300	6	0.938	93.8	3	0.97	97	2	0.98	98

Conclusions

1- Expired Augmentin drugs considered as green corrosion inhibitor as it is a nontoxic inhibitor to human specially at very low concentrations, in addition, prevention of the steel from corrosion is of environmental importance, as corrosion a terrible waste of both natural resources and money.

2- The corrosion inhibition efficiency increase by increasing AUG inhibitor concentrations reach to 98 % at 300 ppm. As soon as the Fe^{+2} ion decreases.

3- The data of AAS show that the ferrous ion Fe^{+2} concentrations were decreased by increasing inhibitor concentration and increased by lowering pH of the solution.

4- The volume of hydrogen evolved during the corrosion reaction of steel in acidic HCl medium was decreased by increasing expired AUG inhibitor concentrations which may due to inhibitor compounds control the hydrogen evolution reaction.

5- The reduction in the reaction number and time delay (Δt_{m}) of the expired AUG inhibitor decrease with increasing the pH value in the following order: pH 3 > pH 2 > pH 1.

6- Results of acidimetric method indicate that the hydrogen ion concentrations decreased in the inhibited medium as inhibitor molecule act as a ligand for protons in acidic environment.

7- The data obtained from different analytical techniques are in good agreement to each other with (±2) to indicate that the addition of expired **Augmentin, AUG** drugs inhibit the corrosion of steel in acidic environment and decrease the iron dissolution process in this environment. So expired **Augmentin, AUG**, drugs act as green corrosion inhibitor.

8- The used expired drugs used in the present study as safe and green corrosion inhibitor for steel is promise for future application towards the carbon steel alloys used in heavy industries including boilers, water tanks, and petroleum pipe lines.

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