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Recycling of Some Water Soluble Drugs for Corrosion Inhibition of Steel Materials: Analytical and Electrochemical Measurements

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The accumulation of the expired vitamin B6 drugs is hazards for both our child's and environment, the present research aimed to reuse the expired water soluble drug in its pharmaceutical form as potential non-toxic corrosion inhibitor for steel alloys used in manufacturer of the petroleum pipe lines in 1.0 M HCl. Atomic absorption spectroscopy(AAS) and electrochemical techniques were used to evaluate the corrosion inhibition efficiency, effect of concentrations and temperature were studied, the data show that the inhibition efficiency was increased with concentrations and decreased with temperature. Potentiodynamic polarization data show that the expired vitamin B6 retard both anodic and cathodic potential meaning it is a mixed inhibitor. The electrochemical impedance spectroscopy EIS, techniques data shows that the expired drug help to increases the polarization resistance by adsorbing on metal/electrolyte interface. This kind of adsorption found to obeying Langmuir adsorption isotherm model. The data obtained from the used techniques exhibit good agreement between them with (± 1) to prove that the used expired vitaminB6 medicinal drugs act as eco-friendly corrosion inhibitor for the steel in acidic environment in its pharmaceutical from.

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Keywords: Corrosion; Green inhibitor; Steel materials; AAS; Potentiodynamic; EIS; Expired drugs.

1. Introduction

Vitamin B6 is one from the water soluble vitamins and is a one from a famous and important vitamin which used in the large amount in our homes for many diseases like anemia, heart deficiency, and many other conditions. Its present in an alcohol form known as pyridoxal. Vitamins consumption increased dramatically with increasing population and with the appearing of new kind of diseases in the world like the covid-19 crises and others virus infections as vitamins is important for increasing the human health in general and supporting the human immunity, Vitamin B 6 one from the most important vitamins used for heart diseases, anemia, and many others conditions [1,2]. Vitamins changed to expired form either by reaching the expired date or by exposure to light or heat all of this leading to accumulation of large amounts of vitamins in our homes and in the environment. Vitamin B6 one from the easy soluble vitamins their accumulation in the environment after it expired is hazards for child's and also cause the pollution of the underground water in the developing countries as it is wasted in the desert through a holes with other medicinal compound so it will reach to the underground water cause a significant pollution for the underground water. Drugs in general is 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

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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 using of the expired medicinal drugs as corrosion inhibitors for the metals and alloys was introduced at the first time by Abdel Hameed 2009 and 2011, [3,4] when he applied the expire drugs ranitidine as potential nontoxic eco-friendly inhibitor for the corrosion of aluminum in hydrochloric acid solution, his work have been take attention of the another scientists and researchers to evaluate and study many of the expired drugs materials as corrosion inhibitors.

Further, the research of unused drugs has been focused on corrosion inhibition of the steel in different corrosive environments [5-13]. 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 soiled waste accumulations but also to introduce a potential nontoxic 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 protection of metals from the corrosion in many industrial fields. Following the green chemistry concepts, the application of expired drugs in the metallic protections of metals helps in the important green condition namely, 1) avoid toxicity by of the toxic inhibitors to human, 2) save both solvent and energy consumed in preparation of others traditional corrosion inhibitors materials. 3)There is no waste while using drugs as inhibitors, in addition, 4) avoid the accumulation of drugs waste which is dangerous on the child’s and ground water, so that the expired drugs considered as green corrosion inhibitors, because There is no any waste for the process of using drugs as inhibitors as it was taken from the drug market directly to the laboratory, where it was used in their pharmacological form in very few doses which is safe for humans and the environment.

In addition, Corrosion is the oxidation process of the metals and alloys by effect of the environments and circumstances, which lead to the formation of the corrosion product in the medium results in the destruction of the metallic crystal, corrosion phenomena cause a terrible waste for both natural resource and money, consequently the control of steel corrosion is of technical, economic and environmental importance, when the corroded steel has been changed from a solid and useful metal to a corrosion product that considered a danger to environment, so controlling the corrosion of steel is a green process. The damage of metals and alloys by the corrosion increase the maintenance cost and need more metals production which is highly expensive process. Finally, expired drugs are a green inhibitor for corrosion as they are a nontoxic inhibitor to both human and environment especially at low concentrations of small doses, plus preventing steel from damage by corrosion has big environmental significance, as corrosion is a terrible waste for money and the natural resources together. Electrochemical techniques are highly effective and widely used for evaluation of large numbers of materials against corrosion protection of many metallic alloys in large types of the aqueous corrosive environment, containing acids, alkaline, and aqueous salts [14-29]. In the previous works [5-7] expired paracetamol, expired Indomethacin, and expired megavit zinc drugs were recycled and applied as inhibitors for the corrosion process of the steel in acidic and sodium chloride corrosive environment using electrochemical and chemical techniques.

The aim of the present work is to recycling of expired vitamin B6 drugs by reusing it as eco-friendly potential nontoxic green inhibitors for corrosion of the carbon steel alloys used in manufactural of petroleum pipe lines and petroleum industries in 1.0 M hydrochloric acid using electrochemical techniques and atomic absorption spectroscopy (AAS). The effect of expired drugs dose and the reaction temperature were studied as soon as the adsorption isotherm mode to reach the corrosion inhibition mechanism of the studied expired vitamin B6 drugs. The survey of the literature [1,2] shows that vitamin B6 was used in a large scale in treatment and preventing the pyridoxine deficiency and many others diseases like anemia, heart diseases, depression, and premenstrual syndrome, also Vitamin B6 is necessary for the proper function of sugars, proteins, and fats in the human body. It is also necessary for the proper development and growth of the brain, skin, nerves, and many others human body parts. the vitamin B6 which is known as pyridoxal compound is a water soluble vitamin naturally present in some foods and available as a dietary supplement and its consists of six membered heterocyclic aromatic ring containing three alcoholic side chain functional group and methyl side chain group in addition of aromatic ring all of this functional group makes from vitamin B6 a highly promise substance as corrosion inhibitor.

2. Experimental and methods

2.1. Used materials and solutions

2.1.1. Materials

The used materials are analytical grade 37% HCl, Na_2CO_3, obtained from Sigma Aldrich chemical Co., Carbon steel samples employed in the study is similar to the carbon steel which used in manufacturer of petroleum pipe line with the gravimetric composition as given in Table 1. Expired vitamin B6 drugs used as corrosion inhibitor in this study was taken from home after expired date by 6 months, vitamin B6 with molecular formula ($C_8H_{11}NO_3$) its chemical composition and structure formula as given in Fig. 1.

Table 1. The gravimetric composition carbon Steel materials used in the study.

Elements	**Manganese**	**Silicon**	**Sulfur**	**Phosphorus**	**Carbon**	**Iron**
Gravimetric composition % Weight	0.5171	0.2013	0.0092	0.0073	0.1600	about 99.00

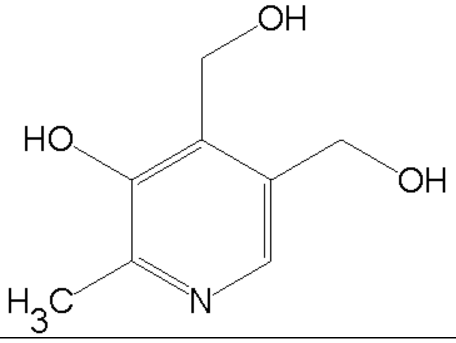
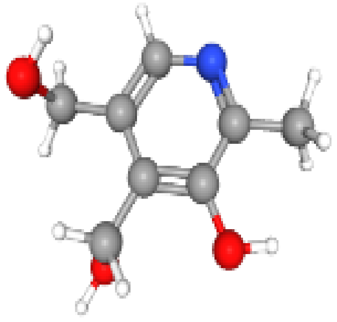
Expired drug chemical name	**Chemical structure**	**3D Structure**
Vitamin B6		

Fig. 1. The 3D and chemical structure formula of Vitamin B6 (pyridoxal compound) inhibitor.

2.1.2. Solution preparation

The corrosive hydrochloric acid of concentration 1.0 M HCl (pH = 0.0) which used as corrosive medium in the present research work was prepared using analytical grade (37% HCl) by dilution by distilled water then standardized by titration with 1.0 M Na_2CO_3, followed by dilution to required appropriate pH.. All experiments were completed with aerated stagnant solution with three-time repetition at the same experimental conditions for reproducibility checking and the mean value of the three readings were taken for the data processing. The inhibitor solution is an expired vitamin B6 drug, in the form of capsules produced by the Gulf Pharmaceutical Industries (JULPHAR) in the form of tablets of 40 mg concentration. The drugs tablets were crushed to obtain the powdered form which dissolved in a hot 5.0% alcoholic water to obtain the inhibitor solution.

2.2. Atomic absorption spectroscopy measurements (AAS)

The quantitative determination of the iron ions passes to the corrosive medium of 1.0 M HCl in the presence of the used expired vitamin B6 drugs as inhibitor were determined by atomic absorption spectroscopy(AAS). Concentration of the ferric ions passed into solution has 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.

2.3. The open circuit potential measurements (OC)

Open circuit potential of the steel electrode was determined against the saturated calomel electrode (SCE) in 1.0 M HCl solution in the presence and absence of various concentrations of inhibitors at 30 ^{O}C. all the measurements were accomplished using Multi-tester until steady-state potential reached.

2.4. The potentiodynamic polarization (PDP)

The radiometer analytical was used to study the electrochemical experiments, type of Volta master (PGZ301, DYNAMIC ELS VOLTAMMETRY). A counter electrode is a platinum wire and the reference electrode to which all potentials are referred is a saturated calomel electrode (SCE). The acting (working) electrode is a steel cylindrical shape (1 cm^2). The surface of the c-steel working electrode was successively polished by silicon carbide abrasive sheets of grades, 800,1100, 1300, 1500, and 2000 before each experiment, followed by washing with bi distilled water, degreasing into ethanol and cleaning with bi distilled water. The used working steel electrode is maintained prior to immersion in free corrosion potential for 50 minutes. The scan rate is 1 mV/s. The % I.E percent of corrosion inhibitory efficiency. was calculated using the following equation [17]:

$$\% I.E. \quad = \quad \left[\frac{i - io}{i}\right] x\ 100 \qquad (1)$$

where as i and io are the values of the corrosion current densities in the absence and presence of the used inhibitors respectively. The cathodic and anodic Tafel slopes were obtained from the Tafel plot and the corrosion potential (Ecorr), corrosion current (Icorr) and Tafel constants (βa & βc) were obtained and tabulated.

2.5. The electrochemical impedance spectroscopy (EIS)

Voltalab 40 was used for all electrochemical impedance spectroscopy, EIS, techniques, the used frequencies ranged from 100kHz to 50mHz with 4 Mv sine wave as the excitation signal at the open circuit potential. If the real part is plotted on the X-axis and imaginary part is plotted on Y-axis of the chart we gain a Nyquist Plot shape. From the difference in the impedance at lower and at higher frequencies the charge transfer resistance values (Rct) was calculated. The polarization resistance Rp, was determined from the diameter of semicircle in the Nyquist plot representation.

3. Results and discussion

Following the green chemistry concepts by elimination of environmental pollution by accumulated waste like expired drugs and corrosion products which considered as environmental and ecological hazards materials, the application of expired materials in the corrosion inhibition process of metals and alloys is of economical, environmental, ethical impact, as the damage of metals by corrosion result in the high cost of maintenance and equipment's. In addition, the high cost and toxic effect of the traditional corrosion inhibitors, in this respect, Vitamin B6 drugs considered as potential nontoxic highly efficient corrosion inhibitor due to its promise chemical constituents. Vitamin B6 drugs is a highly water soluble known as pyridoxal compound which consist of six membered heterocyclic pyridine aromatic ring in addition of three side chain alcoholic functional group and methyl group all of this functional group cause the high inhibition efficiency of it towards the corrosion of seel in acidic environment. This constituent adsorbed on the steel surface and will affect both anodic and cathodic reaction. The corrosion inhibition efficiency was evaluated using high performances electrochemical techniques, namely open circuit potential, potentiodynamic polarization, and electrochemical impedance spectroscopy, EIS. Also high performance atomic absorption spectroscopy(AAS) technique was used to estimate and detect the concentration of iron ions passes into the solution due to corrosion process in the presence and absence of the used expired vitamin B6 inhibitor compound.

3.1. Atomic absorption spectroscopy (AAS).

AAS considered from the simplest and accurate analytical techniques which were used in the estimation and determinations of the transition metals ions in the aqueous environment, in this work it was used in the estimation of the iron ions due to corrosion of steel. Corrosion is a process of oxidation of metals by its surrounding circumstance leading to change of the metal metallic state into ions, atomic absorption spectroscopy(AAS) was used in the determination of the ions concentrations which passes into the solution as a result of the corrosion process, in this case AAS considered as an indirect method for determination of the corrosion rate. As the concentrations of ferrous ions in the solution increases the rate of corrosion increases, when steel was corroded it changed into ferrous ions in the first step then after a certain time it changed into ferric ions. AAS was used to detriment the ferrous ion concentration in the corrosive solution after 8 hours of the immersion of the steel coupons in 1.0 M HCl in the presence and absence of the expired vitamin B6 as inhibitor, effect of inhibitor concentrations and reaction temperature were studied.

Table 2 and Fig. 2 shows the effect of both concentration and temperature on the ferrous ions concentration in the acidic solution. The obtained AAS data as it appears in Table 2 indicated that as the inhibitor concentration increases the ferrous ions concentration decreases consequently the corrosion rate decreases, whereas the concentrations of ferrous ions increase gradually by rising the temperature indicating that the corrosion rate of steel increased with increasing temperature this may be due to the desorption of vitamin B6 molecules from the steel surface due to gradual breaking of coordination bond. 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.

3.2. Open circuit potential measurements

Fig. 3 represent the potential time curves of the carbon steel electrode immersed in 1.0 M HCl solution at 30 ^{0}C in the absence and presence of different concentrations of the expired Vitamin B6 drugs. The open circuit potential was determined against SCE as a reference type electrode for about 50 min. as shown from Fig. 3 the potential E values of c-steel tends towards more negative potential then shifted slightly to the positive direction then reached to steady state. The same behavior was noted with addition the inhibitors bus the steady state potential shifted to more noble direction. The inhibitor molecules raise up the free corrosion potential of c-steel (shift it to the more noble direction) compared to the potential determined in the case of the blank solution. The apparent steady state values are observing always more negative compared to the immersion potential indicating the dissolution of the metal oxide film before the steady state is reached in all curves [8,29].

Table 2. Effect of Expired drugs (Vitamin B6) concentrations on ferrous ion concentrations [Fe^{+2}]as result of AAS technique at different temperatures (30, 40, 50, and 60 ^{0}C).

Sample	**Concentrations of the inhibitors ppm**	**Concentrations of the Ferrous ions pass to the solution due to corrosion process [Fe^{+2}], ppm.**			
		30 ^{0}C	**40**^{0}C	**50** ^{0}C	**60** ^{0}C
Blank	Free	98	121	134	156
Vitamin B6 (pyridoxal) Compound which used as inhibitor	400 ppm	19	23	32	47
	800 ppm	12	17	21	39
	1200 ppm	9	11	17	23
	1600 ppm	5	7	11	15

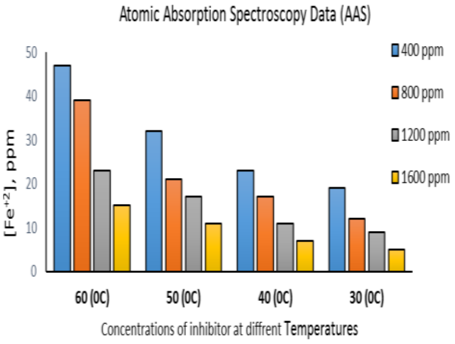


Fig. 2. Effect of Expired drugs (Vitamin B6- (pyridoxal)) concentrations on ferrous ion concentrations $[Fe^{+2}]$ *as result of AAS technique at different temperatures (30, 40, 50, and 60* ^{0}*C).*

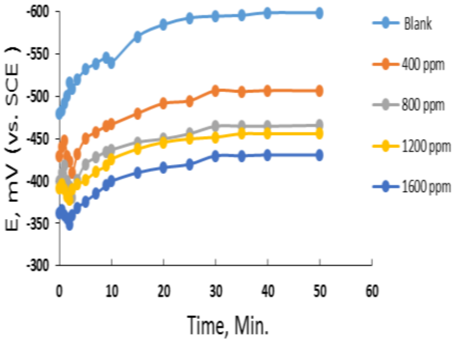


Fig. 3. Variation of potential with time for steel immersed in 1.0 M HCl solution with and without expired Vitamin B6 (pyridoxal) drugs used as green inhibitor at 30 ^{0}*C.*

3.3. Potentiodynamic polarization (PDP) technique

Fig. 4 represent the potentiodynamic polarization (PDP)curves for the carbon-steel electrode immersed in 1.0 M HCl solution with and without different concentrations of expired Vitamin B6 drugs. The electrochemical parameters of corrosion like cathodic (β_c) and anodic(β_a) Tafel slopes were calculated and measured from the linear region of the polarization curves. The values of corrosion current density (I_{corr}) were calculated from the intersection of the anodic and cathodic lines with the corrosion potential ($E_{corr.}$). Percentage of inhibition efficiency (%I.E.) was calculated from corrosion current density values using equation 1(experimental section). Whereas the surface coverage θ values were obtained using the following equation [5-8].

$$\theta = \left[1 - \frac{I_{add}}{I_{free}}\right] \tag{2}$$

where, I_{free} and I_{add} are the corrosion current densities in the free and inhibited acid solutions, respectively. The values of β_a, β_c , E_{corr} ,I_{corr} and %I.E. were listed in Table 3. It can concluded from the Table 3 the followings: the Tafel slopes values β_a and β_c are nearly constant (slightly changed) indicating that the inhibitor molecules affect both anodic and cathodic reactions(mixed inhibitor), this mean that the metal surface area available for both anodic dissolution of steel and the cathodic hydrogen evolution process were decreased without any effect on the reaction mechanism. The slow change in the potential values $E_{corr.}$ to negative values prove that the inhibitor is mixed type mainly cathodic. The I_{corr}.values decreases consequently the I.E's increases proving the inhibition effect of expired Vitamin B6 drugs toward the corrosion of steel in hydrochloric acid corrosive environment.

Table 3. Polarization data of carbon teel electrode in 1.0 M HCl solution containing different concentrations of expired Vitamin B6 (pyridoxal) drugs inhibitor at 30 ^{0}C.

The used inhibitor	Concentrations Ppm	-$E_{corr.}$ mV (SCE)	$I_{corr.}$ mA, cm^{-2}	β_a $mVdec^{-1}$	β_c $mVdec^{-1}$	**% I.E.**	**θ**
Blank	Free	487	1.3	99	121		
Vitamin B6 (pyridoxal) Compound which used as inhibitor	400 ppm	519	0.15	111	128	88.5	0.885
	800 ppm	527	0.12	122	136	90.7	0.907
	1200 ppm	539	0.1	131	141	92.3	0.923
	1600 ppm	543	0.07	139	147	94.6	0.946

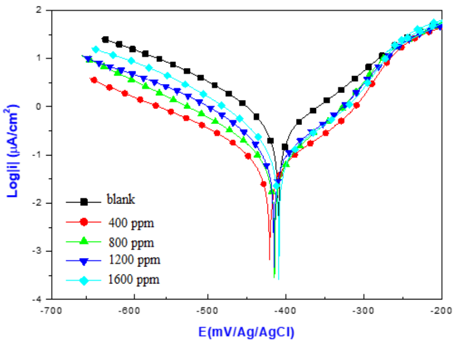


Fig. 4. Potentidynamic polarization (PDP) curves for carbon steel in 1.0 M HCl containing different dose from the expired Vitamin B6 (Pyridoxal compound) drug inhibitor at 30 ^{0}C.

3.4. Electrochemical impedance spectroscopy (EIS) measurements

Electrochemical impedance spectra Nyquist plots obtained for corrosion inhibition of steel in 1.0 M HCl containing different doses from the expired megavit drugs as green inhibitor at 30 ^{0}C is shown in Fig. 5. The Nyquist plots contain depressed semicircle with center under real axis. The semicircle size increases with the inhibitor concentration, suggesting the charge transfer process is the main controlling factor of the steel corrosion. It is apparent from the plots that; the impedance of the inhibited solution has increased with the increase in expired drug inhibitor concentrations. The EIS experimental results for corrosion of c-steel in 1.0 M HCl in presence and absence of expired Vitamin B6 inhibitor is given in Table 4.

Table 4. AC Impedance data for carbon-steel electrode in 1.0 M HCl solution at 30^o C with and without various concentrations of the expired Vitamin B6 (Pyridoxal compound).

Sample	**Expired Drug Concentrations ppm**	**Rct Ohm cm^2**	**Rs Ohm cm^2**	**Cdl μ F cm^{-2}**	**% I.E.**	**θ**
Blank	Free	86.5	2.6	35.0	- -	- -
Vitamin B6 (pyridoxal) Compound which used as inhibitor.	400 ppm	799.6	1.9	4.7	89.2	0.892
	800 ppm	950.4	2.4	3.1	90.9	0.909
	1200 ppm	1133.6	1.7	2.4	92.4	0.924
	1600 ppm	1311.2	1.5	1.3	93.4	0.934

As showed from the data the values of polarization resistance (R_p) increased with increasing the inhibitor concentration. Whereas of the capacitance of the interface (C_{dl}) values starts in decreasing, by increasing the inhibitor concentrations, this may be due to the decrease in the local dielectric constant and/or increase in thickness of the electrical double layer. This suggests that the drugs inhibitor molecules act via adsorption at the metal/solution interface [5-10] and the decrease in the C_{dl} values is caused by the gradual replacement of water molecules by the adsorption of the inhibitor molecules on the electrode surface, which decreases the extent of metal dissolution process.

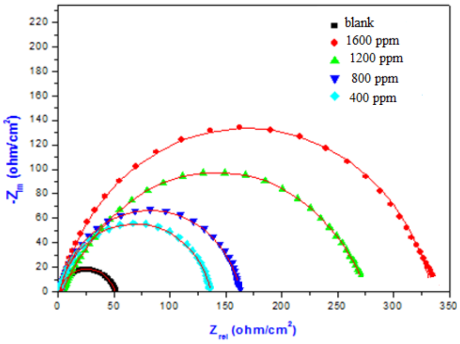


Fig. 5. The Nyquist plots for carbon-steel electrode in 1.0 M HCl solution with and without different concentrations of expired Vitamin B6 drugs (Pyridoxal compound) as green inhibitor at 30⁰ C.

The corrosion inhibition efficiency is given by the following equation [25-32]:

$$\% I.E. = \frac{Rp(inhi) - Rp}{Rp(inhi)} \quad x\,100 \qquad (3)$$

where R_p is polarization resistance without inhibitor, and R_p(inhi) is polarization resistance with inhibitor. C_{dl} value is obtained from the following equation:

$$\omega\,(max) = 2\,\pi\,f\,(max) = \frac{1}{Rp\,Cdl} \qquad (4)$$

where, f($_{max}$) is the frequency at the top of the semicircle (where-Z" is maximum). The proposed equivalent circuit is represented in Fig. 6 the electrode impedance, Z, in this case given by the mathematical equation [35-41]:

$$Z = \mathrm{Rs}\ \left[\frac{Rt}{1+(2\,\pi\,\mathrm{f}\,Rt\,Cdl)^{\alpha}}\right] \qquad (5)$$

where α represents the empirical parameter (0 ≤ α ≤ 1) and f is equal to the frequency (in Hz). The equation number 5. Takes into account the normal deviation from the ideal RC behavior in view of the term of a time constant distribution process due to the surface heterogeneity, roughness effect, adsorption of the inhibitor, and the variation of properties or the composition of the surface layers. The suggested equivalent circuit Fig. 6 consists of the double-layer capacitance (C_{dl}) in parallel to the charge transfer resistance (R_t) which is in series to the parallel inductive (Rs).

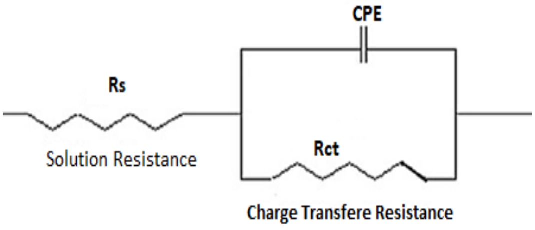


Fig. 6. The suggested circuit as equivalent for solution resistance, charge transferee resistant, and CPE. Related to (EIS) Electrochemical Impedance Spectroscopy Measurement.

3.5. Adsorption isotherm

The process of the adsorption affected mainly by the metal charge, metal surface nature, electronic characteristic of the metal surface, the temperature of the reaction, the presence of the electro repelling or electro donating groups in the derivatives, the solution-interfaces electrochemical potential, adsorption of the solvent and other ionic species.

Tafel polarization values are used to calculate the surface coverage (θ) values in the presence of different inhibitor concentrations and to reach the best fit isotherm, many adsorption isotherms were applied but the obtained results are completely agreed to the Langmuire adsorption isotherm as given from equation number (6) [32]:

$$\frac{Ci}{\theta} = \frac{1}{Kads.} + Ci \qquad (6)$$

where, K_{ads} and Ci are the constant of the adsorption process and the concentration of the drugs, respectively [32]. Graphical representation of Ci/θ against Ci is a straight line shape as represented in the figure 5. The slope of the obtained strait line nearly equal unity with intercept equal 1/K. The standard free energy for the adsorption process $\Delta G°_{ads}$ is given from the following mathematical equation:

$$Kads = \frac{1}{55.5} \exp(\frac{-\Delta G}{RT}) \qquad (7)$$

where K_{ads}. Is the equilibrium constant of the adsorption process, the value 55.5 equal the water concentration at the bulk of the solution(mole/liter), the absolute temperature is T, and R is the gas constant. The calculated value of ΔG_{ads} is (-36.5 kJ/mole). The value of the free energy of adsorption ($\Delta G°_{ads}$) is negative to indicate on the spontaneous adsorption process of the drugs molecules on the metal surface[32]. On the other hand, the obtained value is less than the reported value (-40 Kj/mol) necessary for chemical adsorption this observation indicates that the adsorption mechanism is a physical adsorption type mechanism [30-35]. It can be concluded that the expired drug materials inhibit corrosion by the adsorption of its constituent molecules on the metal /electrolyte interface. Some researchers have been believed that the formation of passive film from the solid organic drug molecule on the atoms of the metal at the surface this suggestion is the most acceptable in the present case because the Vitamin B6 drugs is a high complex mixture from multivitamins, polysaccharides, plant extract, and minerals as mentioned in experimental part, all the constituent help in the formation of stronger adhesive film on the steel surface preventing steel from the corrosion by attached corrosive environment[36-41]

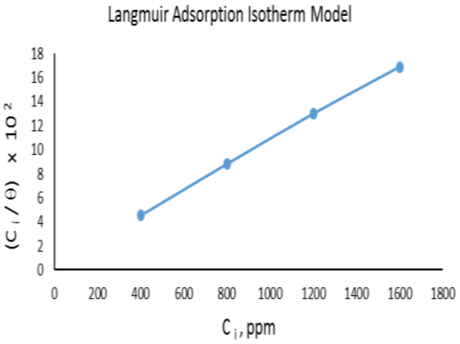


Fig. 7. Langmuir isotherm for adsorption of Vitamin B6 (Pyridoxal compound) on the surface of the carbon steel immersed in 1.0M HCl solution at 30 °C.

4. Conclusions

Expired Vitamin B6 drugs considered as eco-friendly corrosion inhibitor as it is a nontoxic inhibitor to the human being at the used low concentration, also the prevention of steel and metals from corrosion is of big impact from the environmental chemistry point of view. Electrochemical measurements are of higher performance and accurate in evaluation of steel corrosion and in evaluation of the inhibition performance of the inhibitors. The corrosion inhibition efficiency increase by increasing expired Vitamin B6 drugs inhibitor concentrations reach to 94.6 % at 1200 ppm.

The high corrosion inhibition efficiency of the expired Vitamin B6 drugs due to its adsorption on metal surface. The high corrosion inhibition efficiency of the expired Vitamin B6 drugs due to its complex component mixture of multivitamins, plant extract, polysaccharides, nicotinamide, and minerals. Potentodynamic polarization measurements results indicated that the values of $E_{corr.}$ change slowly to more negative values to indicate that the expired Vitamin B6 inhibitors are of the mixed type inhibitors which affect both anode and cathode. Electrochemical impedance spectroscopy data indicating that the semicircle size increases by increasing inhibitor concentrations suggesting that the process of charge transfer is the controlling factoring steel dissolution process. Corrosion inhibition process due to adsorption and adhesion of expired Vitamin B6 drugs on steel surface forming a passive layer on the steel surface which separate the steel from aggressive media the adsorption fit well with the Langmuir isotherm of adsorption.

The data obtained from the used electrochemical techniques exhibit good agreement between them with (± 1) to prove that the used expired Vitamin B6 medicinal drugs act as green corrosion inhibitor for the c-steel in 1.0 M HCl acidic environment. So expired Vitamin B6 drugs act as potential non-toxic corrosion inhibitor.

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