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Study of the Corrosion inhibitor for Steel XC70 in different Concentrations of acid and at room temperature of N-mesitylimidazole

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Abstract

In this paper, we study the effectiveness of corrosion inhibition of X70 carbon steel in the acidic medium HCl 1M at different concentrations and at ambient temperature using the compound prepared in laboratory in France this compound is: N - mésitylimidazole. This study was conducted at analytical laboratory and the inhibitory. We have used two methods: conventional method of weight loss and the method of electrochemical polarization curves (impedance spectroscopy). The results obtained by the method of weight loss have shown that the inhibitory effectiveness of this compound is greater than 96%, while it is around 65% for the electrochemical method. Through adsorption curves Langmir and Timken, we find that there was adsorption of this compound on the metal surface.

Keywords: Corrosion, steel XC70, Inhibition, adsorption isotherms.

Introduction

Corrosion results from a chemical action or electrochemical environment on metals and alloys. The consequences are important in various fields, particularly in industry: production stop, replace corroded parts, accidents and pollution risks are frequent events with sometimes heavy economic implications.

The facilities and industrial equipment susceptible to corrosion can be designed and implemented taking into account the corrosion treatments available. Different treatments are already known and for existing facilities. However, the use of several different metals (ferrous and non-ferrous) and the prohibition of toxic inhibitors (chromate, nitrite, etc.) complicate the implementation of an effective treatment against corrosion and thus justify the search means of protection.

Corrosion inhibitors are a wholly owned means of protection against metal corrosion. They have the distinction of being the only response from the corrosive environment, making it a method of controlling the corrosion easy to implement and inexpensive, as long as the product or products to be used a moderate cost. Numerous studies have been conducted for fifty years, these compounds have yielded offer products or mixtures of specific products corresponding to corrosion systems (metal corrosive medium pairs) given. Each case corrosion remains a special case, and it is necessary to know the database operation of these inhibitors, their operational limitations[1-3]. The thermodynamic and kinetic data allow the adsorption phenomenon to explain inhibitors on the surface of a metal[2-4]. Using both methods, weight loss method and electrochemical[1,5]

Our research project which we have chosen is to fix a new inhibitor heterocyclic base, in order to combine their inhibitory property.

Material and Methods

^{1}H NMR spectra and ^{13}C NMR were recorded on BRUKER AVANCE DPX 200 spectrometers and AM300WB equipped with a QNP probe multi-cores. The chemical shift of the signals (δ) are expressed in ppm and signals correlated to $CDCl_3$ (1 H: 7.26 ppm, 13 C: 77.00 ppm (the central peak)).

The synthesized product spectrum was performed at room temperature (≈22°C air conditioned room), the product and analyzed in $CDCl_3$.

1H NMR characteristics are given as follows: δ (ppm) (m multiplicity, intensity I, coupling constant J (Hz), assignment).

The progress of reactions was typically controlled by a thin layer chromatography. The plates used are of Merck Silica gel type 60 F254. The revelation of the plates is carried out by UV (254 nm) exposure to iodine, or an acid $KMnO_4$ solution. The product was purified on silica gel column (SDS 60 - 0040-0063 mm, 230-400 mesh).

Glassware is stored in an oven at 100°C. Upon release, the Schlenk tubes were sealed and placed under vacuum with a ramp composed of a vacuum line and a line under argon. The vacuum ramps range from 0.01 to 0.05 mm Hg.

Protocol: Weight loss tests were performed by setting a sample on a polymer support queue in a beaker containing 40 ml of the electrolyte. A water bath was used to help maintain electrolyte at room temperature. The samples used are rectangular and have a total area of 14.30 cm^2 (two + side faces). The samples are rinsed with distilled water and finally drying. The samples are weighed before and after each test and in the end there is a microscopic photograph of a surface of the workpiece before and after the soak.

Results and Discussion

We studied the influence of the concentration of hydrochloric acid on the corrosion of the metal XC70, it was tested for the following concentrations: 2.65774 * 10^{-5} M to 26.58 * 10^{-5} M. The rate of corrosion is determined after 30 min of immersion, to an ambient temperature.

Based on results we have shown that the corrosion rate increases when the concentration of HCl acid 1M increases. Susceptibility to corrosion material is a function of the number of protons in the electrolyte. High proton concentration in the solution increases the aggressiveness of the environment.

Among the factors that affect the rate of corrosion of steel, we include the factor of the immersion time, so for this we tested different immersion time of the steel that is 05 min to 50 min HCl medium 1M.

Analysis of the results in table 1 clearly shows that the steel corrosion rate in HCl 1M decreases with the increase of immersion time. This decrease is due to the spontaneous formation of the protective layer adsorbed to the metal surface decreases the dissolution of the latter.

The effect of the inhibitor N-mésitylimidazole on corrosion of steel in acidic medium. For this we studied the influence of concentration on the corrosion of steel.

The experimental conditions used are: i. Concentration of HCl acid 1M, ii. The temperature is of the ambient temperature solution.

The test compound concentration range is between 2.65774 * 10^{-5} M and 26.58 * 10^{-5} M.

The inhibitory effectiveness was determined after 30 min of immersion, at room temperature, table 2 gives the values of the corrosion rate (V) and the percentage of the inhibitory efficacy R% calculated gravimetrically for different concentrations of HCl medium inhibitor 1M.

From the results obtained in table 2 we can make the following remarks: i. The addition of this compound to the corrosive medium has an influence on the steel corrosion rate. This decrease in velocity (V) is probably due to adsorption of the compound to the metal surface[3]. ii. The corrosion rate decreases as the inhibitory efficiency increases with the concentration of the inhibitor. This behavior could be attributed to the strong interaction of the inhibitor with the metal surface; it is clear from the adsorption of molecules on the metal surface[4]. iii. The adsorption of the compound on the metal surface can be attributed to nitrogen atoms, their electronic pair to the metal in the presence of the active site to the metal surface and make connections between them the inhibitory efficacy of this compound varies a compound to another, with a better inhibitory efficiency (96.45%) 21.26 * 10^{-5} M.

Table–1
Corrosion rate and time of immersion of the steel in HCl 1M Room temperature

t (min)	S (cm^2)	Δm(g)	Vg/(cm^2. min *10^{-3})
05	14.28	0,009	3,1512605
10	14.28	0,01	7,00280112
15	14.29	0,0115	11,6515045
20	14.27	0,0118	16,538192
25	14.26	0,0322	56,4516129
30	13.10	0,037	84,7328244
35	13.99	0,033	82,5589707
40	14.20	0,027	76,056338
45	14.24	0,02	63,2022472
50	14.27	0,017	59,5655221

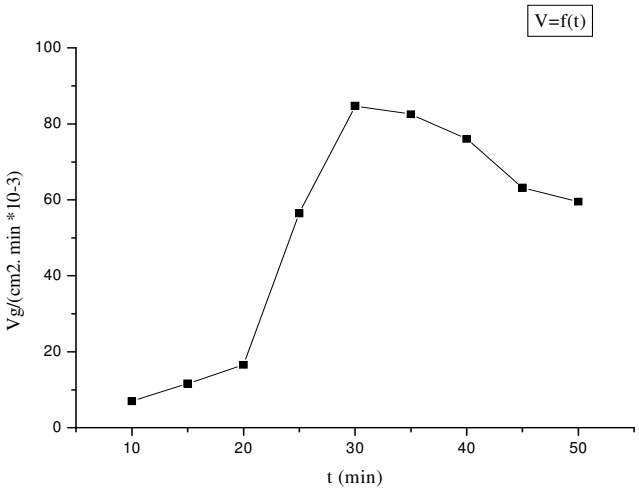

Figure-1
Evolution of speed of corrosion as a function of time HCl 1M at room temperature.

Electrochemical study: Figures 4, 5 represent the cathode and anode polarization curves of steel, in medium acid HCl 1M. without and with addition of the inhibitors at various concentrations. The electrochemical parameters derived from these curves are shown in table 3.

From these results we can make the following remarks: i. The cathodic polarization curves are in the form of lines showing that the reduction reaction of hydrogen at the steel surface follows a pure activation mechanism. ii. The action of inhibitor results in a decrease of the anodic and cathodic currents. This result shows that the addition of inhibitor reduces the anodic dissolution of iron and retards the development of the discharge of H^+ ions. iii. The addition of inhibitor is slightly various in the values of the cathode slope bc. This result suggests that the proton reduction mechanism is substantially unaffected by the addition of the inhibitor. iv. The corrosion potential varies little with the increase of the concentration of the inhibitor, thus confirming the mixed nature of the inhibitor with all times slightly anodic density. The best concentration which reduces the corrosion rate is 40 ppm.

The cathode displacement of the curves shows that N-mesityimidazol is placed on the cathodic sites of the metal surface.

The recovery rate values θ for different concentrations of the inhibitors obtained from weight loss measurements in the temperature range studied were used to determine the corresponding isotherm adsorption of the inhibitor process. Thus the different Langmuir isotherm consisting were tested to find the suitable adsorption isotherm. These adsorption isotherms were used for the other inhibitor[3]. According to these isotherms, θ is related to the concentration of the other inhibitor C_{inh}.

Curve C_{inh} / Θ according to the concentration is linear for the N-mésitylimidazole Figure 6, this shows that the adsorption of N-mésitylimidazole on the surface of the steel in HCl medium 1M obeys isotherm Langmuir adsorption $R_2 = 0.841$.

The electrochemical impedance spectroscopy (henceforth EIS) is established a powerful tool in the study of corrosion, the surface properties, the kinetics of the electrode and the information on the mechanism can be obtained from the diagrams impedance.

Figure 7 shows the Nyquist plots of the steel interface solution, obtained in the potential drop in 1M HCl. The steel electrode being previously modified or not with a film of N-mésitylimidazole obtained after immersing the electrode for 30 min in a solution of the inhibitor at various concentrations. These graphs are made up of a main capacitive loop form of a semicircle whose center is located below the real axis. This type of chart usually indicates that the corrosion reaction is controlled by a charge transfer process on a solid electrode heterogeneous and irregular surface[5].

We observe more than the diameter of the capacitive loop representing, recall, charge transfer resistance (Rt) is greater in the case of N-mésitylimidazole electrode previously modified, in the case of the control (unmodified steel). A protective film is therefore well spontaneously self-assembled on the surface of the metal after the simple immersion of the article in the solution containing the dissolved molecules of the inhibitor. Thus formed effectively protects the steel due to its blocking effect of the transfer of metal from the surface of electrons to the corrosive solution.

In studying the effect of the inhibitor (N-mésitylimidazole) where the concentrations vary from 5 to 50 ppm and the following curves were obtained:

Table-2
Corrosion rate and inhibitory efficacy of the corrosion in 1M HCl added the inhibitor at room temperature

C (ppm)	S (cm^2)	Δm (g)	V g/(cm^2. min)	V (mm/an *10^{-3})	%R
00	13.20	0,0391	0,08886364	59,8804196	0000
05	14.30	0,0052	0,01090909	7,35104895	87,7237852
10	14.33	0,0059	0,01235171	8,32315207	86,1003778
15	14.28	0,0038	0,00798319	5,37944408	91,0163554
20	14.27	0,0048	0,0100911	6,79984906	88,6442862
25	14.28	0,0032	0,00673212	4,53641169	2,42421521
30	14.27	0,004	0,00840925	5,66654089	90,5369052
35	14.28	0,0028	0,00588235	3,9638009	93,3804724
40	14.28	0,0015	0,00315126	2,12346477	96,4538245
45	14.28	0,002	0,00420168	2,83128636	95,271766
50	14.27	0,0051	0,01072179	7,22483963	87,9345541

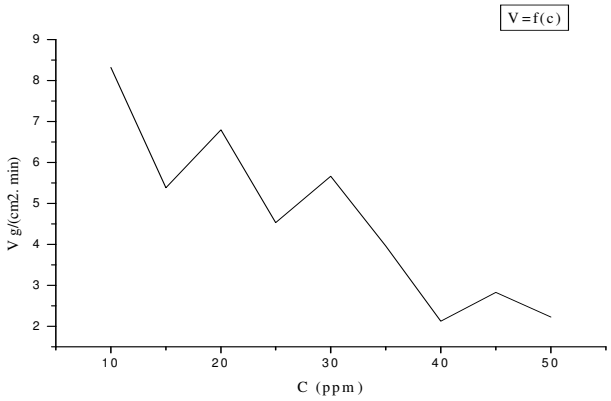

Figure-2
Evolution of the speed of corrosion depending on the concentration of the inhibitor

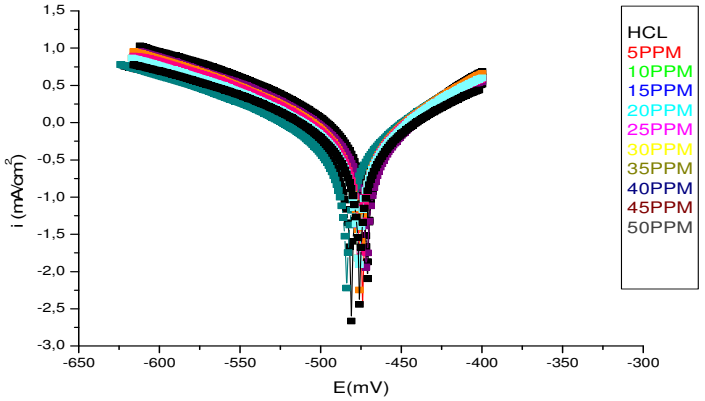

Figure-5
The Polarization curve of Steel in 1M HCl without and with the addition of different concentrations of N-mesityimidazol

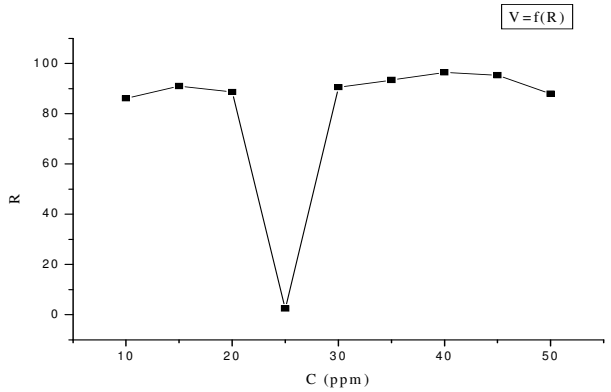

Figure-3
Evolution of the inhibitory efficiency as a function of inhibitor concentration

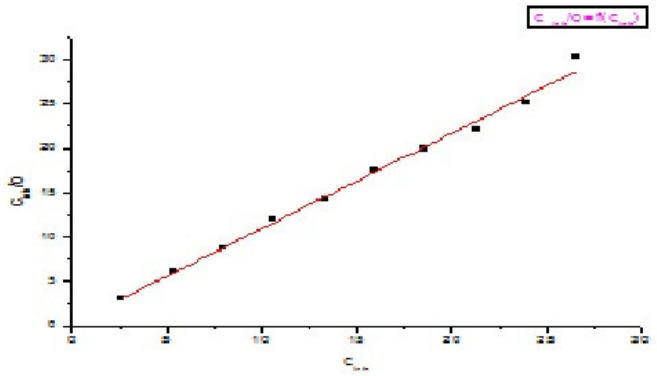

Figure-6
Langmuir adsorption isotherm of steel in HCl 1M

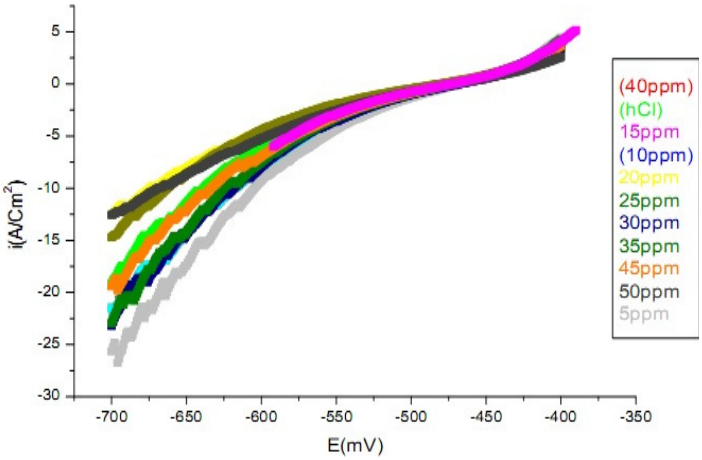

Figure-4
The polarization curve of the XC70 steel in a 1M HCl solution

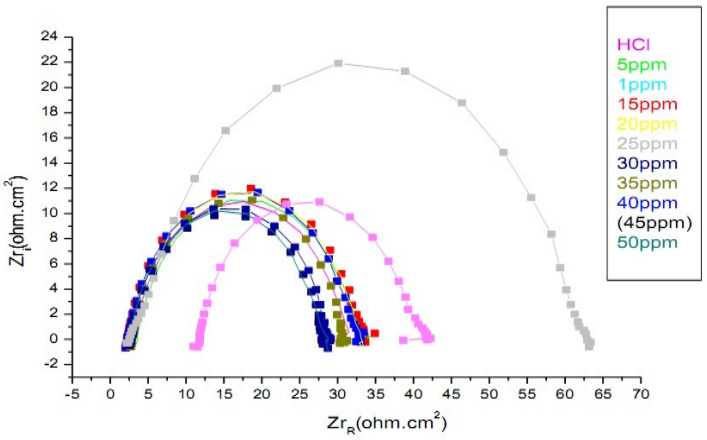

Figure-7
Nyquist curves XC70 for electrode in an HCl solution 1 M in the absence and in the presence N-mésitylimidazole of 05-50 ppm

Table-3
The electrochemical most important values of N-mesityimidazol in HCl solution 1M

C (M) *10^{-5}	-E (mv)	Icorr(mA .cm^{-2})	ba(mv)	bc(mv)	Vcorr mm/an	R%
00	471.2	1.5053	138.5	-165.5	17.60	/////
2,65774	471.4	1.2865	140.6	-166.1	15.04	14,5454545
5,31547	471.6	1.0575	133.6	-150.2	12.36	29,7727273
7,97321	476.4	0.5643	88.8	-112.2	6.599	62,5056818
10,63	475.6	0.9484	123.3	-146.7	11.09	36,9886364
13,29	473.8	0.7694	133.7	-150.9	8.999	48,8693182
15,95	476.4	0.6861	94.6	-123.0	8.024	54,4090909
18,6	475.8	0.6496	89.1	-110.4	7.598	56,8295455
21,26	481.1	0.5214	100.3	-123.8	6.098	65,3522727
23,92	483.8	0.5308	93.9	-123.2	6.208	64,7272727
26,58	483.9	0.6532	90.2	-120.2	7.806	55,6477273

Table-4
The impedance parameters of XC70 electrode in a HCl solution 1 M in the absence and presence of 05-50 ppm of N-mésitylimidazole

C (M) *10^{-5}	RCT*10^3 (ohm)	ZR max (ohm.cm^2)	Zi max (ohm.cm^2)	Fmax*10^2 (Hz)	C*10^{-5} (µF)
00	45.66	3.98296	1.47729	15.8230	6.80870
2,65774	13.65017	4.228	1.2260	12.333	7.6589
5,31547	15.6882929	4.19067	4.468	4	9.02895
7,97321	40.71892023	4.50959	3.64528	4	1.0915
10,63	33,68273558	4.40141	4.1364	3.55	9.6236
13,29	43.04524368	5.58828	5.6498	2.5	1.12694
15,95	52,19756989	3.89963	2.71536	6.32910	9.26085
18,6	25.08986242	3.51276	2.73658	6.3291	9.18904
21,26	25.32234182	3.55756	2.7754	6.3291	9.06026
23,92	25.64534046	1.4568	5.717	2.5	0.11133
26,58	52.93074911	8.41629	9.42303	2.5	6.75600

The size of the impedance spectrum also increases with the concentration of the inhibitor and the value of Rt, determined from the difference between the low frequency limit and the upper limit frequency of the real part of the total impedance, achieved the maximum concentration of 13.29 * 10^{-5} M. This result validated below by modeling using different equivalent circuits EEC, reflects the influence of N-mésitylimidazole film on the processes taking place in acid medium steel interface. This film becomes more effective effect when the concentration of inhibitor increases.

Conclusion

In this work we have followed the inhibitory action of the N-mésitylimidazol used as inhibitor of corrosion of carbon steel XC70.

The study was conducted in the following settings: HCl 1M. The measurement was performed by the mass loss method, and electrochemical method as the polarization curves and electrochemical impedance spectroscopy.

First, we studied the behavior of the steel in HCl medium 1M alone, and the factors that affect the steel corrosion rate of acid concentration and immersion time. For this study we used the weight loss method. The results show that the corrosion rate increases with the increase of the concentration of the medium. For this we found that the test compound is very effective.

The Nyquist curves showed that a XC70 electrode impedance parameters in an HCl solution 1M in the absence and presence of N-mésitylimidazol inhibitor indicating that it is essentially a charge transfer process.

Acknowledgements

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