CORROSION INHIBITION OF CARBON STEEL
BY USING SOME BENZOTRIAZOLE DERIVATIVES IN 0.5M H₂SO₄ MEDIUM

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The inhibitory effect of some benzotriazole derivatives 5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 mercato-1,2,4 benzotriazole on the corrosion behavior of carbon steel in 0.5M H₂SO₄ medium at temperature of 25°C was studied by potentiodynamic polarization, electrochemical impedance spectroscopy (EIS), Fourier transform infrared spectroscopy (FT-IR) and metallurgical microscopy techniques. The effect of inhibitor concentration on the corrosion rate, surface coverage and inhibition efficiency is investigated. Results show that these organic inhibitors exert a strong inhibiting effect on carbon steel corrosion and acts as a mix-type inhibitor. The inhibition efficiency of organic inhibitors may be due to either the adsorption of inhibitor molecules building a protective film or the formation of an insoluble complex of the inhibitor adsorption obeys the Langmuir model. Further, characterization using FT-IR demonstrates the adsorption of inhibitors and the formation of corrosion products on the carbon steel surface. EIS results confirm its corrosion inhibition ability.
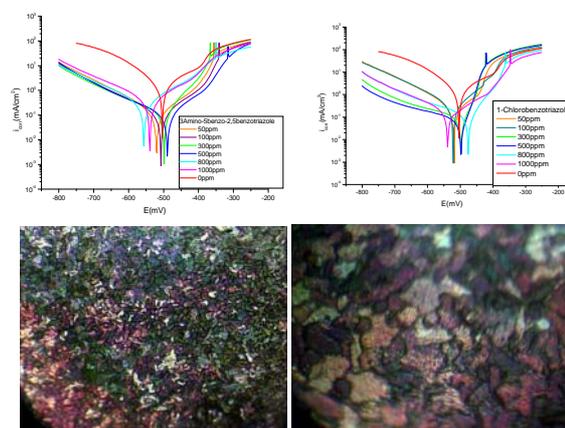
INTRODUCTION

Carbon steel is widely used in many applications; this intensified the research in corrosion resistance in various aggressive environments.[1-4] Acid solutions are large scale used in many industrial processes. Acid sulphuric, acid phosphoric and hydrochloric acid are aggressive solutions used for acid pickling of steel and ferrous alloys, acid cleaning and acid rescaling due to their special chemical properties. Treatment of the corrosive medium for the protection of metals can be realized through elimination of the corrosive species or through the use of inhibitors. The use of inhibitors is one of the most important methods for protection of carbon steel against corrosion in acidic media.[5-8] Through all inhibitors, the most important are the organic ones, also called adsorption inhibitors. As they usually affect the whole metal surface, when are present in sufficient concentration, they cannot be called anodic or cathodic inhibitors. Many organic compounds containing polar groups including nitrogen, sulphur and oxygen and heterocyclic compounds with polar functional groups and conjugated double bonds have been reported to inhibit corrosion for carbon steel in various aggressive environments.[9-13] The inhibiting action of these organic compounds is usually attributed to their interactions with the metal surface by adsorption. The effect of some

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triazole derivatives has been reported earlier as corrosion inhibitors for steel, and they reveal that the inhibition efficiencies of these compounds are much greater than that of the corresponding amines and aldehydes. There are few reports about the successful use of Schiff base derived from aromatic aldehydes and amines, compounds containing aminic nitrogen as corrosion inhibitors for carbon steel in acidic media.[14-19] Recently, the application of triazole derived Schiff bases as corrosion inhibitors has been studied by some authors, suggesting that Schiff bases have good inhibition properties for the corrosion of many metals in various aggressive media. The available data show that these compounds were selected as inhibitors. In the present work, the aim of this study is to report on the inhibition effect of some benzotriazole derivatives: 5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 benzo-2, 5 benzotriazole on the corrosion behavior of carbon steel in 0.5M H_2SO_4 medium at temperature of 25°C. In this study, the inhibition of carbon steel corrosion in 0.5M H_2SO_4 by organic compounds was investigated by potentiodynamic polarizations, electrochemical impedance spectroscopy (EIS), Fourier transforms infrared spectroscopy (FT-IR) measurements and metallography analysis.

EXPERIMENTAL

All benzotriazole derivatives (5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 mercato-1,2,4 benzotriazole) were of analytical grade acquired from Fluka. Bidistilled water was used for solution preparations. The studied metals were the carbon steels type OL 37 with composition: C% 0.15; Si% 0.09; Mn% 0.4; Fe% 99.293; P% 0.023; S% 0.02; Al% 0.022; Ni% 0.001; Cr% 0.001. The working electrode for electrochemistry measurements was prepared from a cylindrical carbon steel rod with area 0.5 cm^2. This shape is preferred, because it ensures a greater surface and a reduce number of edges. The working electrode was mechanically polished on wet silicon carbide (SiC) papers (1200, 2500, 4000 grid) rinsed with bidistilled water, degreased with acetone and ethanol and dried at room temperature. The aggressive environment used was 0.5M H_2SO_4 solution prepared from analytical reagent grade chemicals and bidistilled water.

The polarization behavior of carbon steel in aqueous solutions of 0.5M H_2SO_4 in presence and absence of organic inhibitors has been studied by potentiostatic and potentiodynamic methods. The inhibitory action was studied through tracing the polarization curves obtained using the potentiodynamic method calculation of the kinetic parameters of corrosion in case of solutions with inhibitors, especially the corrosion current densities, and their comparison with the kinetic parameters of the solution without inhibitors. The

polarization curves were obtained by potentiostatic and potentiodynamic methods.

Potentiostatic, potentiodynamic and EIS measurements were carried out by using the conventional three electrodes set up; the cell was connected to an automated model VoltaLab 40 potentiostat/galvanostat. A platinum sheet served as counter electrode (CE), a saturated calomel electrode (SCE) as the reference electrode and a working electrode made of carbon steel type OL37. All the potential values gives in this study were measurements with respect to this electrode at a temperature of 25^{0}C. Fourier transform infrared spectroscopy (FT-IR) was used to identify whether there was adsorption of organic inhibitor on the surface of the metal was performed with Bruker Optics. Metallurgical microscopy techniques was obtained with Hund H600 microscope.

RESULTS AND DISCUSSION

In this study, the inhibition of the corrosion is the result of the adsorption of the organic compound on the metal surface forming an invisible film of a few molecular diameters thickness. The inhibition activity analysis of the organic compound was made by assuming that the mechanism of inhibition by organic molecules is chemisorption

The polarization behaviour of carbon steels mentioned above was studied through the plotting of the polarization curves obtained using the potentiodynamic method, finding the kinetic parameters of corrosion (especially the density of the corrosion current) from solutions without inhibitors and their comparison with the kinetic parameters from solutions with different concentrations of inhibitor. The corresponding Tafel parameters were obtained by Mansfeld's method, employing polarization data near the corrosion potential. In the present paper, when values of E-E_{cor} are higher than about 70 mV, slight but significant changes in the anodic and cathodic Tafel slopes were found. Figs. 1-3 show a series of potentiodynamic polarization curves of carbon steels electrode in (it was not aerated) in absence and presence of different concentrations of benzotriazole derivatives.

Both anodic and cathodic polarization curves for carbon steel in 0.5M H_2SO_4 at various concentrations of this benzotriazole derivatives are shown in Figs. 1-3. It is clear that the presence inhibitors cause a markedly decrease in the corrosion rate, i.e. shifts the anodic curves to more positive potentials and the cathodic curves to more negative potentials. This can be assigned to adsorption of inhibitor over the carbon steel surface.
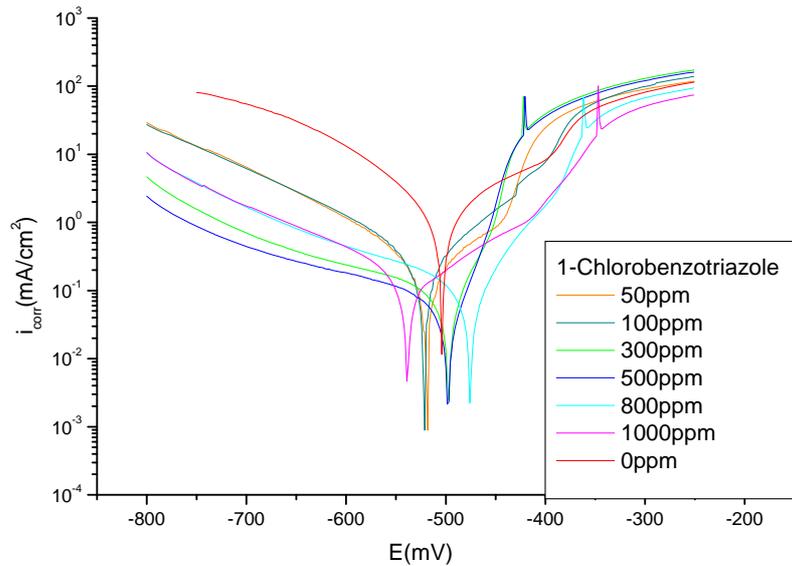
Fig. 1 – Polarization curves of OL 37 in 0.5M H_2SO_4 +Xppm 5-Chlorobenzotriazole at temperature of 25°C.

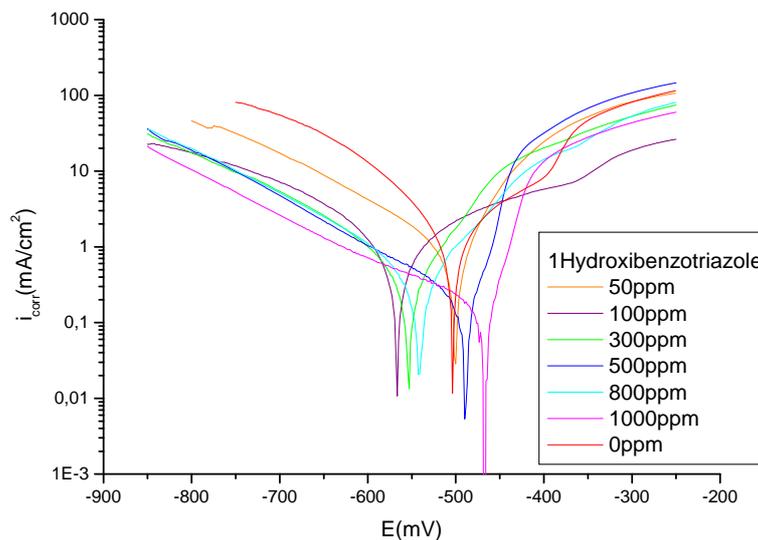
Fig. 2 – Polarization curves of OL 37 in 0.5M H2SO4+Xppm 1Hydroxibenzotriazole at temperature of 25°C.

The results suggest that the three inhibitors act as a mixed-type inhibitor with predominant cathodic effectiveness for chlorobenzotriazole, which works mainly by increasing the hydrogen evolution potential in the H_2SO_4 solution, makes the corrosion potential negative shift and slows the cathodic and anodic process of the carbon steel. Thus, the corrosion reaction of OL 37 is inhibited.

Analysis of the polarization curves from Figs. 1-3 indicates that the $_{maximum}$ efficiency is obtained at the inhibitor concentration of 300ppm and 500ppm for the system: 5-Chlorobenzotriazole+OL37-H_2SO_4, 500 ppm and 1000ppm for the system: 1-Hydroxybenzotriazole+OL37-H_2SO_4, 100ppm and 500ppm for the system 3-amino-5 mercato-1,2,4 benzotriazole +OL37-H_2SO_4. At the increasing inhibitor concentration over these concentrations (300 ppm and 500 ppm) the inhibitor efficiency starts to decrease, respectively the corrosion current densities begin to increase again.

Electrochemical corrosion kinetics parameters, *i.e.* corrosion current density (i_{corr}), corrosion potential (E_{corr}), cathodic and anodic Tafel slopes (b_a, b_c), Rp (polarization resistance) obtained from the Tafel extrapolation of the polarization curves were given in Tables 1-3. Analyzing these tables, it can be observed that the addition of the organic inhibitor to the amounts shown in Tables 1-3 leads in all the cases to inhibition of the corrosion process. All the studied of these organic inhibitors (5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 mercato-1,2,4 benzotriazole) showed a very good inhibition properties for the corrosion of carbon steel in 0.5M H_2SO_4 and the corrosion current density decreased and the inhibitor efficiency increased with increasing inhibitors concentrations.
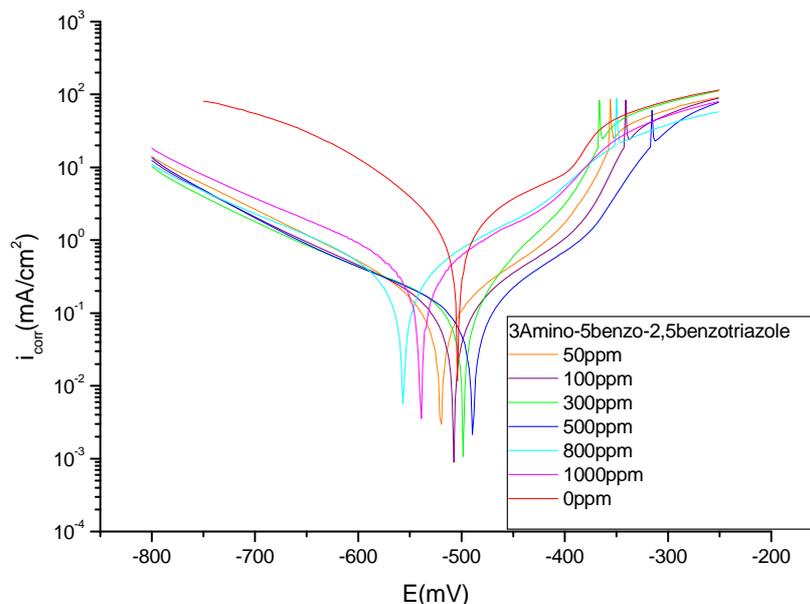
Fig. 3 – Polarization curves of OL 37 in 0.5MH$_2$SO$_4$ +Xppm 3-amino-5 mercato-1,2,4 benzotriazole at temperature of 25°C.

Table 1

Kinetic corrosion parameters of OL 37 in 0.5M H$_2$SO$_4$ in presence and absence
of organic inhibitor type 5-chlorobenzotriazole at temperature of 25°C

Concentration (ppm)	i_{corr} (mAcm^{-2})	R_p Ωcm^{-2}	R_{mpy}	$P_{mm/year}$	K_g g/m^{2}h	E (%)	$-E_{corr}$ (mV)	b_a (mVdec^{-1})	$-b_c$ (mVdec^{-1})	θ
0	1.095	14.16	511	12.96	11.61	-	506	101	83	
50	0.146	90.23	68.13	1.729	1.543	86.6	520	83	79	0.86
100	0.205	71.94	95.66	2.428	2.17	81.25	522	81	91	0.81
300	0.0415	201.7	19.36	0.491	0.44	96.22	500	35	72	0.96
500	0.0158	277	7.37	0.187	0.167	98.55	498	24	35	0.98
800	0.0993	171.7	46.34	1.176	1.053	90.93	478	61	169	0.90
1000	0.073	133	34.06	0.864	0.774	93.33	539	91	59	0.93

Table 2

Kinetic corrosion parameters of OL 37 in 0.5M H$_2$SO$_4$ in presence and absence
of organic inhibitor type 1Hydroxybenzotriazole at temperature of 25°C

Concentration (ppm)	i_{corr} (mAcm^{-2})	R_p Ωcm^{-2}	R_{mpy}	$P_{mm/year}$	K_g g/m^{2}h	E (%)	$-E_{corr}$ (mV)	b_a (mVdec^{-1})	$-b_c$ (mVdec^{-1})	θ
0	1.095	14.16	511	12.96	11.61	-	506	101	83	
50	0.692	20.65	323.16	8.202	7.34	36.75	503	54	113	0.36
100	0.452	28.9	211	5.35	4.79	58.7	568	86.6	76	0.59
300	0.291	45.52	135.8	3.44	3.086	73.34	556	68	86	0.73
500	0.204	72.37	95.3	2.42	2.16	81.33	491	31	145	0.81
800	0.333	52.28	155	3.944	3.52	70	544	85	112.5	0.70
1000	0.172	88	80.59	2.045	1.83	84.22	472	23	435	0.84

Table 3

Kinetic corrosion parameters of OL 37 in 0.5M H$_2$SO$_4$ in presence and absence
of organic inhibitor type 3-amino-5 mercato-1,2,4 benzotriazole at temperature of 25°C

| Concentration (ppm)	i_{corr} (mAcm^{-2})	R_p Ωcm^{-2}	R_{mpy}	$P_{mm/year}$	K_g g/m^{2}h	E (%)	$-E_{corr}$ (mV)	b_a (mVdec^{-1})	$-b_c$ (mVdec^{-1})	θ
0	1.095	14.16	511	12.96	11.61	-	506	101	83	-
50	0.088	188	41.1	1.04	0.934	91.9	521.6	96	98	0.91
100	0.085	209	39.66	1.01	0.90	92.23	508	93	118	0.92
300	0.096	163	45.12	1.145	1.025	91	502	62	141	0.91
500	0.087	213	40.6	1.03	0.923	92	490	90.3	144	0.92
800	0.226	83	105	2.676	2.39	89	557	107	123	0.89
1000	0.266	69	124	3.15	2.82	76	540	105	113	0.75
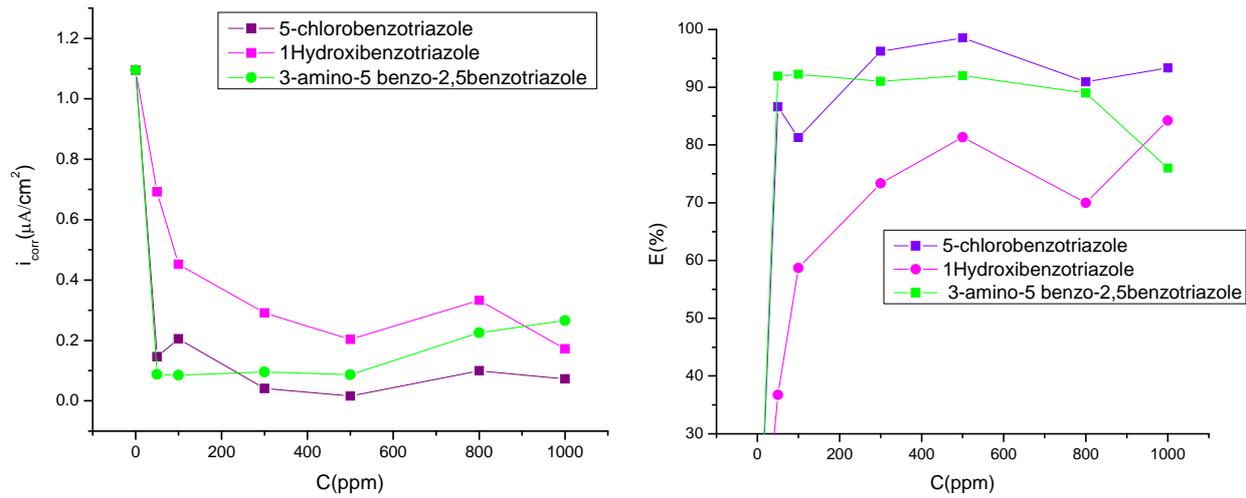
Fig. 4 – The influence of the inhibitors 5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 benzo-2, 5 benzotriazole concentration on the corrosion rate and efficiency of the carbon steel in 0.5M H$_2$SO$_4$ at 25°C.
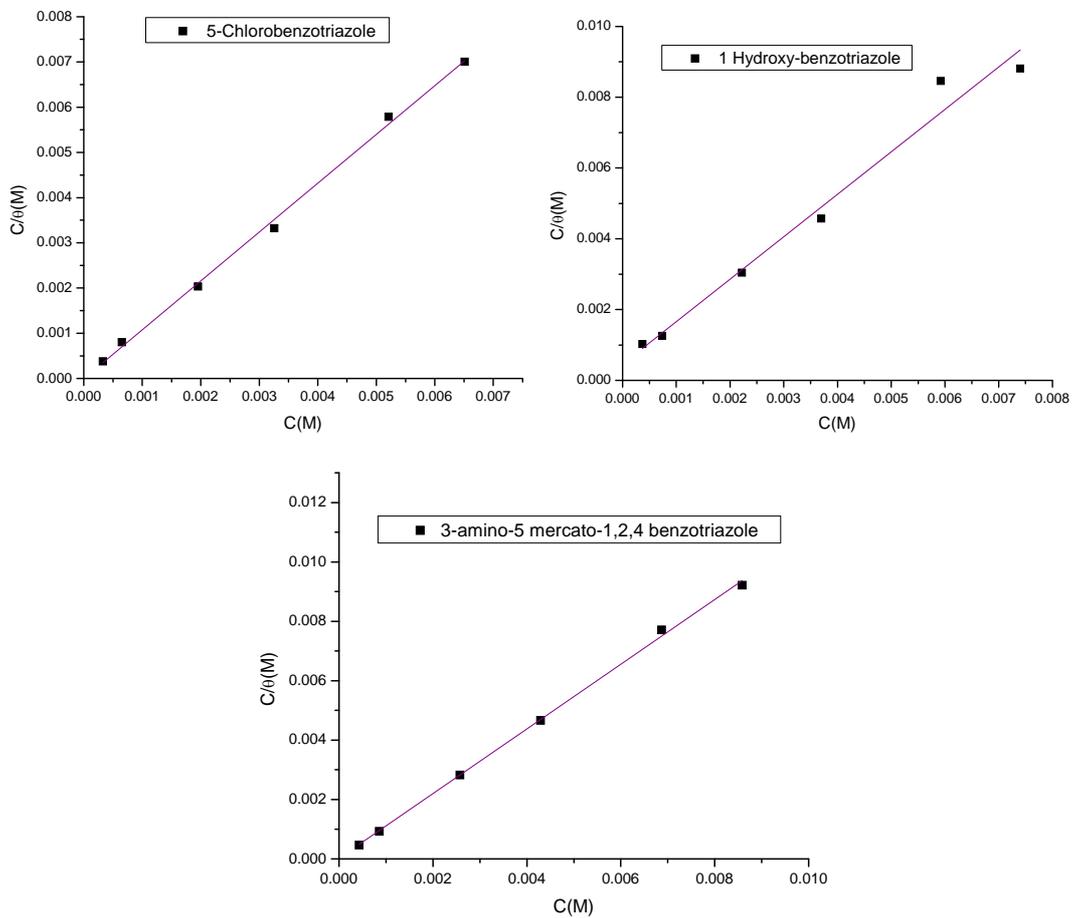

Fig. 5 – Langmuir plot for 5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 mercato-1,2,4 benzotriazole in 0.5M H$_2$SO$_4$ at different inhibitor concentrations.

The variation of inhibition efficiency and current density with inhibitor concentrations is shown in Fig. 4. The inhibition efficiency increased with increase in concentration and from Fig. 4, one can see much better the influence of these parameters on the polarization behaviour of the carbon steel in 0.5M H$_2$SO$_4$ (see Fig. 4). It is obvious from the figures that all these compounds inhibit the corrosion of carbon steel

in 0.5M H_2SO_4 at all concentrations used in this study.

Adsorption of organic compounds can be described by two main types of interaction: physical adsorption and chemisorption processes, which are influenced by the nature and charge of the metal, the chemical structure of the inhibitor and the type of electrolyte. To quantify the effect of inhibitor concentration on the corrosion rate, it is common to fit the rate data to equilibrium adsorption expressions, such as Langmuir equation: $\theta/(1-\theta)=KC$, where θ is the fraction of surface coverage by the inhibitor and K is the equilibrium constant for the adsorption reaction. θ is given by: $\theta = (i_{corr}-i_{inh})/i_{corr}$, where i_{inh} and i_{corr} are the corrosion rates in 0.5M H_2SO_4 with and without inhibitor. Usage of the Langmuir treatment is often justified with the argument that inhibition must involve adsorption.

In this study, the Langmuir isotherm is plotted against C, when a linear relationship is obtained for each inhibitor and a slope of near unity for each compound indicated approximate Langmuir behavior (see Fig. 5). Moreover, we shall try to show what kind type of adsorption process takes place on the electrode surface. The high value of the adsorption equilibrium constant reflects the high adsorption ability of this inhibitor on brass surface.

The adsorption equilibrium constant (K_{ads}) is related to the standard free energy of reaction (ΔG_{ads}^o) by the equation: $\ln K_{ads} = -\left(\Delta G_{ads}^o / RT\right)$.

The negative values of ΔG_{ads}° suggest that the adsorption of inhibitor molecule onto carbon steel surface is a spontaneous process. The values of up to -20kjmol[-1] are consistent with electrostatic interaction between the charged molecules and the charged metal – physical adsorption, while those more negative than -40kjmol[-1] imply sharing or transfer of electrons from the inhibitor molecules to the metal surface to form a coordinative type of

bond – chemisorption. It can be seen from table 4 that the value of ΔG_{ads}° is around -33.73 KJM[-1] for 5Chlorobenzotriazole and -27.0173 KJM[-1] for 3Amino-5benzo-2,5 benzotriazole, which indicate the adsorption of this inhibitors is mainly the chemisorption, the value of ΔG_{ads}° is around -19.05 KJM[-1] for 1-Hydroxy-benzotriazole which indicate the adsorption of this inhibitor is the physical adsorption.

The impedance response of OL 37 in 0.5M H_2SO_4 solution showed significant changes after addition of the inhibitors. This indicates that the impedance of carbon steel increases with increasing the inhibitor concentration.

The Nyquist diagram obtained with 0.5M H_2SO_4 shows only one capacitive loop and the diameter of the semicircles increases on increasing the inhibitor concentration suggesting that the formed inhibitive film was strengthened by the addition of inhibitors.

The obtained impedance spectra do not present perfect semicircle, which can be seen as depressed capacitive loops. This phenomenon is characteristic for solid electrodes and often corresponds to frequency dispersion which has been attributed to roughness and other in homogeneities of electrode surface. The semicircular appearance shows that the corrosion of steel is controlled by charge transfer and the presence of inhibitor does not change the mechanism of dissolution. Fig. 6 also indicates that the diameters of the capacitance loops in the presence of 500ppm and 300ppm 5-Chlorobenzotriazole +OL37 in 0.5MH_2SO_4, 300ppm and 500ppm 3-amino-5 mercato-1,2,4 benzotriazole +OL37-0.5MH_2SO_4 and for 1000ppm 1-Hydroxy-benzotriazole +OL37-0.5MH_2SO_4 are bigger than those in the absence of organic inhibitors, suggesting that has good anticorrosion performance on the carbon steel in 0.5M H_2SO_4.

Table 4

The values of K_{ads} and ΔG_{ads}° for studied systems

The system	Type of metallic material	Values of K_{ads}, M[-1]	Values of ΔG_{ads}° KJM[-1]	Type of adsorption
5Chlorobenzotriazole+0.5M H_2SO_4	OL-37	$8.25*10^5$	-33.73	Chemisorption and Physical adsorption
1-Hydroxy-benzotriazole+0.5M H_2SO_4	OL-37	$2.92*10^3$	-19.05	Physical adsorption and Chemisorption
3-amino-5 mercato-1,2,4 benzotriazole +0.5M H_2SO_4	OL-37	$5.461*10^4$	-27.01	Chemisorption and Physical adsorption

Bode diagrams presented in Fig. 7 are in accordance with Nyquist diagrams. It can be observed that in absence of organic inhibitor the electrode presents one time constant corresponding to a phase angle of about 40º at medium and low frequencies, this fact indicates an inductive behaviour with low diffusive tendency. On the contrary, in the presence of the organic inhibitor, on the curve-phase angle versus log frequency appears a maximum very well defined corresponding to a phase angle of about 75-80° which means that in this case the electrode has a strong capacitive behaviour, according with the results obtained by electrochemical polarization and in concordance with the Nyquist diagrams. Bode diagrams shows that the values of the impedance and phase angle also increase gradually with increasing inhibitor concentration, indicating the formation of a protective film.

The equivalent circuit that describes our metal/electrolyte interface is shown in Fig. 8, where for analysis of the impedance spectra containing a single capacitive semicircle, the standard Randle's circuit is used (Fig. 8), as the circuit is composed of Rs, refer to solution resistance, Rct charge transfer resistance and CPE constant phase element, respectively.[19-24] The high frequency limits correspond to Rs, while the lower frequency limits corresponds to Rs+Rct. The resistor Rs capacitance is series to Rct and Rct is parallel in to the double layer capacitance.

Polarization curves and EIS results consistently indicate that this organic inhibitor protects the surface from corrosion. This is indicated by the increases in charge transfer resistance and the decrease in double layer capacitance, which are in turn the consequence of the participation of the benzotriazole derivatives inhibitor in the protective layer.
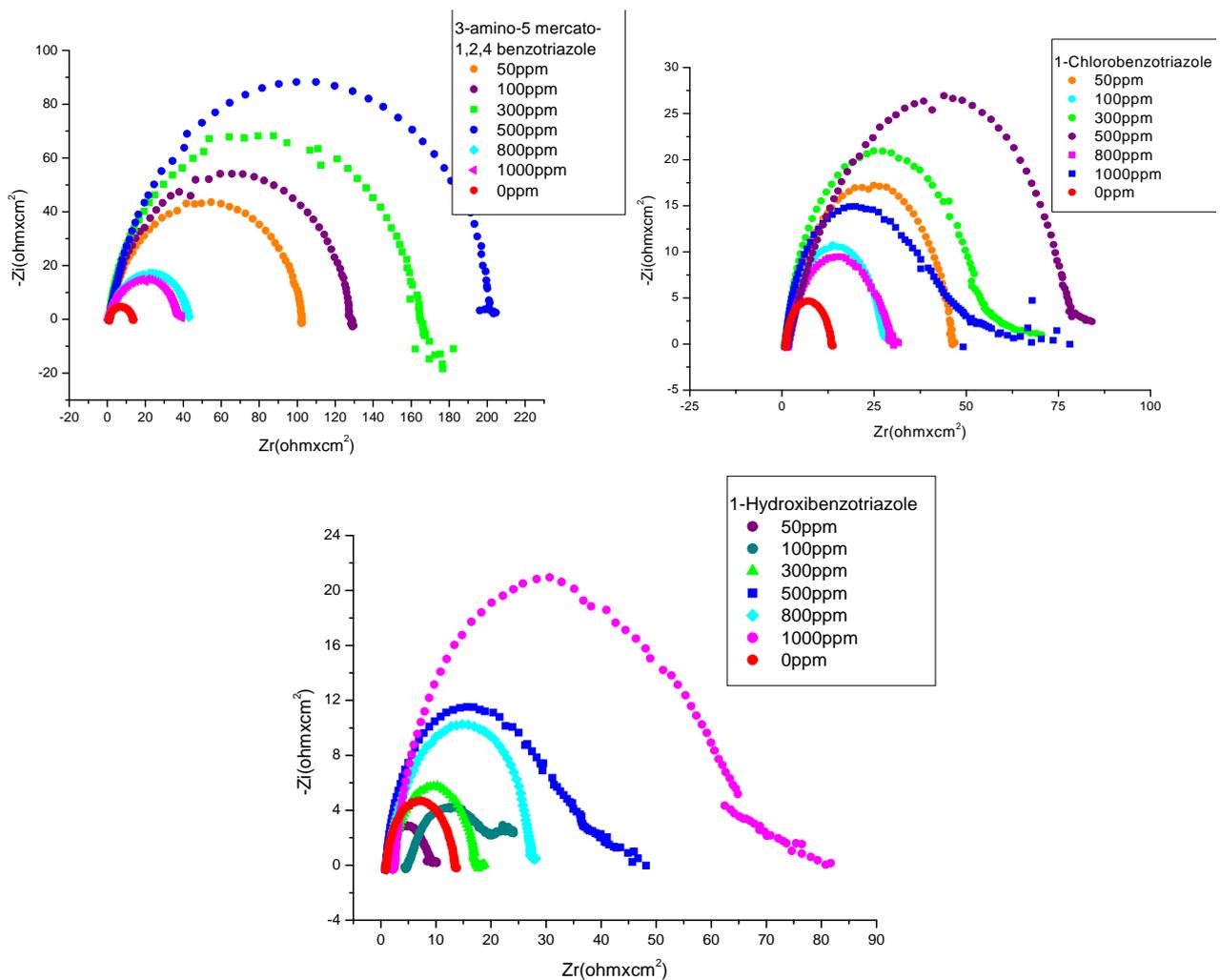

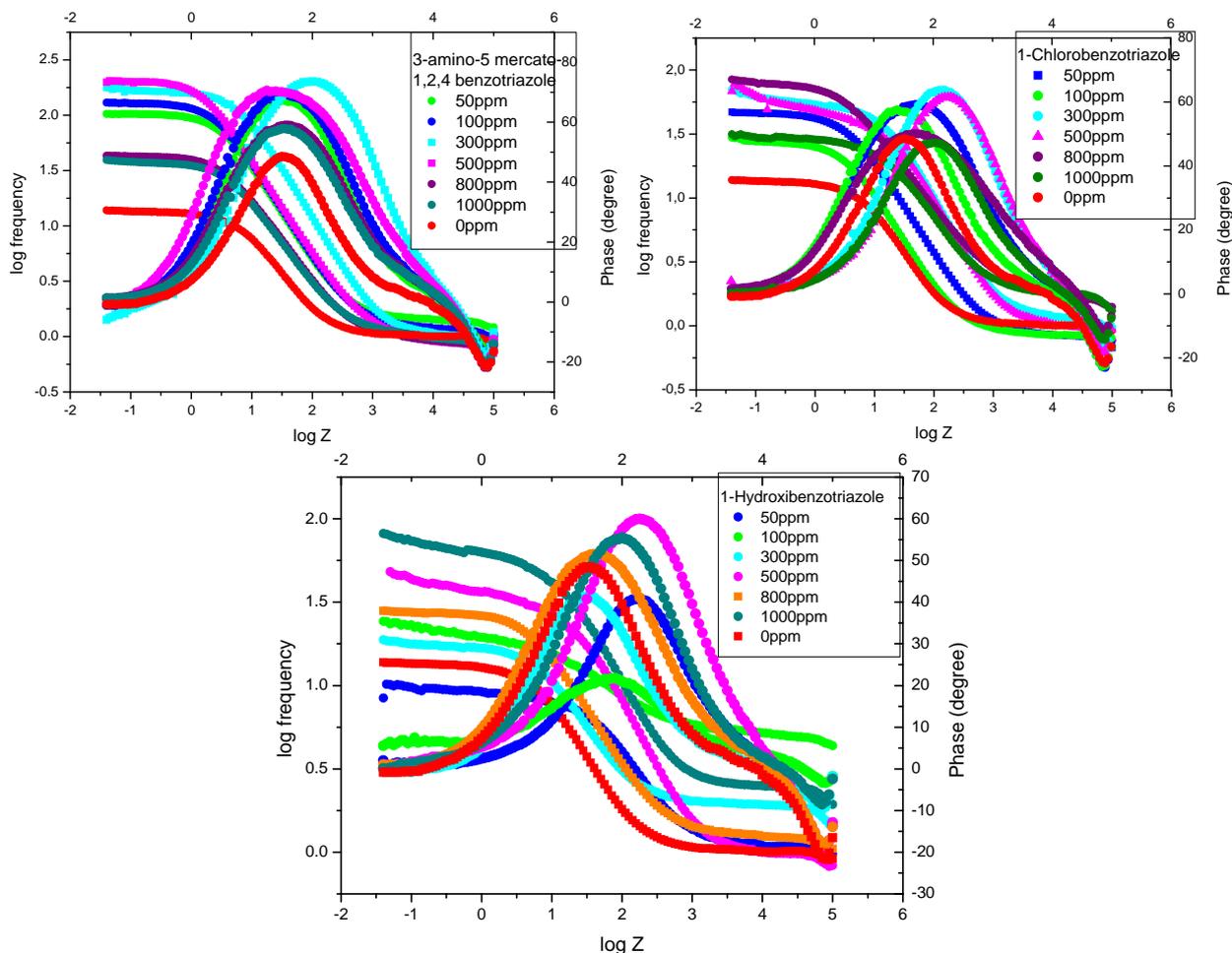Fig. 6 – The Nyquist plot for OL37 in 0.5M H_2SO_4 with and without organic inhibitor.

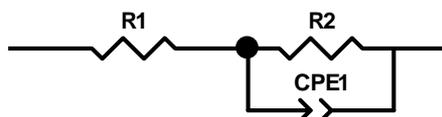Fig. 7 – The Bode plot for OL37 in 0.5M H$_2$SO$_4$ with and without organic inhibitor.

Fig. 8 – Equivalent circuit.

In order to investigate the adsorption behaviour of inhibitor on the surface of carbon steel, spectrometer Bruker optic with ATR was used to measure the spectra of the corroded surface of OL 37 in 0.5M H$_2$SO$_4$ containing organic inhibitors. All spectra in these experiments were obtained at a resolution 4 cm^{-1} in the region 650- 4000 cm^{-1}.

Figs. 9-11 show the FTIR spectra of 5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 mercato-1,2,4 benzotriazole and the corrosion surface of carbon steel in 0.5M H$_2$SO$_4$ in presence of these inhibitors.

A transmission vibrational spectrum of 1-Hydroxybenzotriazole is depicted in Fig. 9a. The band in the region from 3545 to 3138 cm^{-1} is attributed to N-H stretching and that at 3064 cm^{-1} to C-H. Vibration of benzene ring in heteroaromatic compound gives rise to absorption bands at 1615 and 1469 cm^{-1}, the band at 1450 is due the vibration of heteroaromatic ring. The band at 1318 cm^{-1} is attributed to C-N stretching.

The transmission FT-IR spectra obtained for carbon steel type OL37; immersed in 0.5M H$_2$SO$_4$ containing 1000 ppm 1-Hydroxybenzotriazoleorganic inhibitor is presented in Fig. 9b. This shows the characteristic bands for that adsorbed 1-Hydroxybenzotriazole on the metal surface. A weak band in the range from 3593 to 3279 cm^{-1} is due to the protonated amine. The presence of N-N, N=N, C-N and C-H and is indicated by their stretching modes at 1655, 1544, 1317 and 1116 cm^{-1}. For this system an additional band at 680 cm^{-1}, is observed that is characteristic of iron–benzotriazole complex.
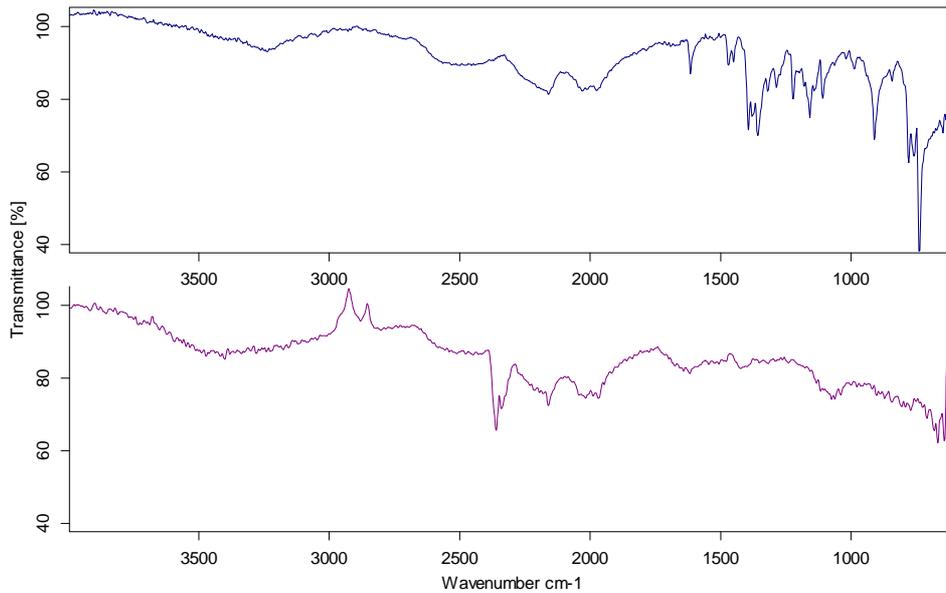
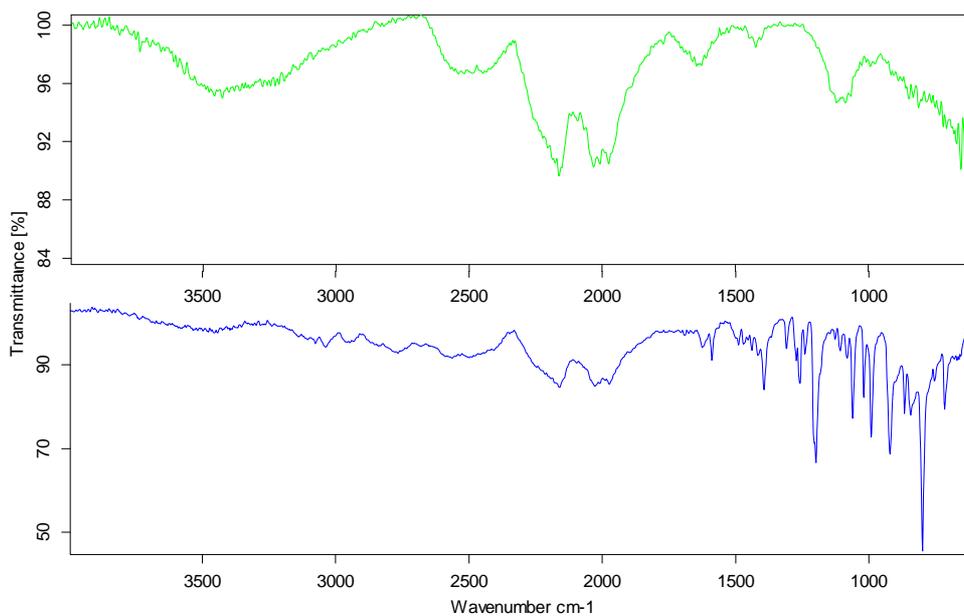Fig. 9 – FT-IR spectra of (a-blue) 1-Hydroxybenzotriazole (b- purple) OL 37+1000 ppm 1-Hydroxybenzotriazole +0.5M H_2SO_4 .

Fig. – 10 FT-IR spectra of (a-blue) 5-Chlorobenzotriazole (b- green) OL 37 +500ppm 5-Chlorobenzotriazole +0.5M H_2SO_4.

The FTIR spectra of 5-Chlorobenzotriazole are shown in Fig. 10a, a peak at 1624 cm^{-1} indicates presence C=N bond and the appearance of a very weak band in the region of 3352 cm^{-1} corresponds to the OH stretching vibration. The presence of C-N and C-H stretching frequencies are clearly manifest in the region 1060 cm^{-1} and 1308 cm^{-1}. Further, peaks at 1580-1488 cm^{-1} can be attributed to the N-N group present in the ring and the C=C ring stretching peak appears at 1439-1393 cm^{-1}. The peak for N-H stretching modes can be seen in the region at 3582-3075 cm^{-1}. The transmission FT-IR spectra obtained for carbon steel type OL37

immersed in 0.5M H_2SO_4 containing 500 ppm 5-Chlorobenzotriazole organic inhibitor is presented in Fig. 10b. This shows the characteristic bands for that adsorbed 5-Chlorobenzotriazole on the metal surface. A weak band in the range from 3567 to 3265 cm^{-1} can be assigned to the presence of N-H. The presence of C=N, N-N, C=C, C-N and C-H and is indicated by their stretching modes at 1626, 1422, 1383, 1066 and 1112 cm^{-1}. The bands 3820 cm^{-1} and 3736 cm^{-1} are attributed to Fe-O bending. This is already confirmed from the Langmuir adsorption isotherm studies.
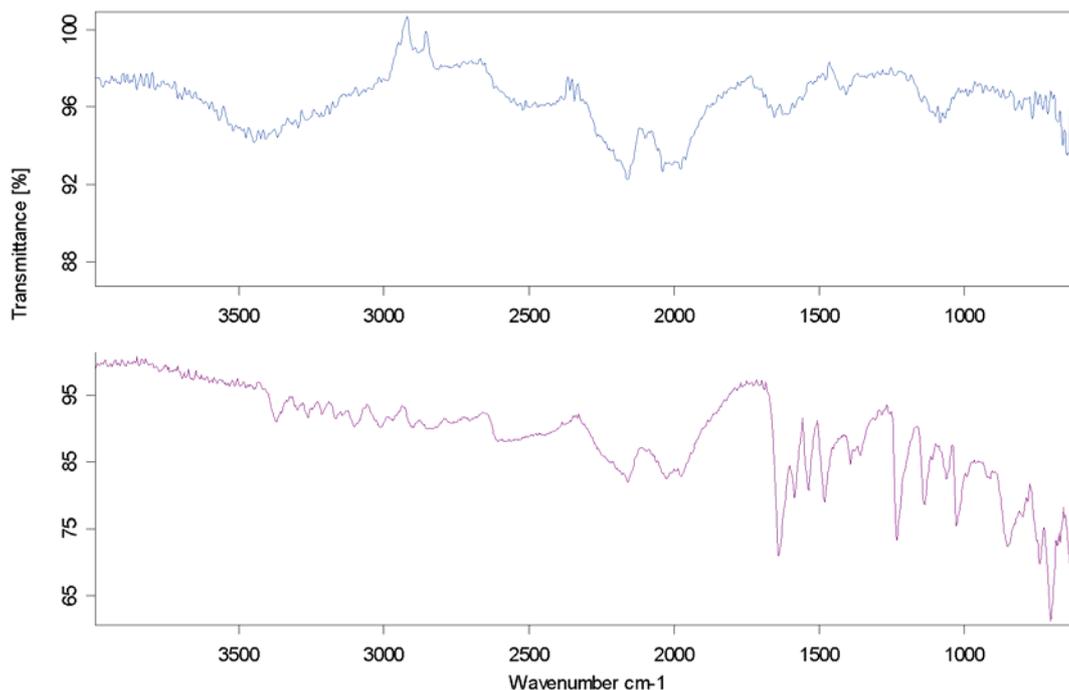
Fig. 11 – FT-IR spectra of (a-purple) 3-amino-5 mercato-1,2,4 benzotriazole (b-blue)
OL 37 +100ppm 3-amino-5 mercato-1,2,4 benzotriazole +0.5M H_2SO_4.

FT-IR spectra of 3-amino-5 mercato-1,2,4 benzotriazole are presented in Fig. 11a and FT-IR spectra obtained for carbon steel type OL37 immersed in 0.5M H_2SO_4 containing 100ppm 3-amino-5 mercato-1,2,4 benzotriazole organic inhibitor is presented in Fig. 11b. From Fig. 11a, N-H stretching vibration exhibits absorption in the region 3372 to 3103 cm^{-1}, C-H stretching vibration in benzene ring shows the absorption at 3014 and 1137 cm^{-1}, C-N exhibits at 1377 cm^{-1}. Furthermore, peaks at 1584-1481cm^{-1} can be attributed to the N-N group present in the ring and the C=C ring stretching peak appears at 1477-1358 cm^{-1} and the C=N stretching vibration at 1639 cm^{-1}. The presence of S-C and S-H stretching frequencies is clearly manifest in the region 2899 and 2260 cm^{-1}. From figure 11b, it shows the characteristic bands for that adsorbed 3-amino-5 mercato-1,2,4 benzotriazole on the metal surface: the broader band arround in the range from 3567 to 35195 cm^{-1} can be assigned to the presence of N-H. The presence of C=N, N-N, C=C, C-N and C-H and is indicated by their stretching modes at 1654, 1558, 1407, 1083 and 1147 cm^{-1}. The presence of S-C and S-H stretching frequencies is clearly manifest in the region 2932 and 2563 cm^{-1}. Moreover, these FT-IR measurements indicated at 3664 cm^{-1} the direct bonding between Fe atoms and 3-amino-5 mercato-1,2,4 benzotriazole molecules via O and N atoms, and the formation Fe-inhibitor complex and this reveal that there is only chemical adsorption occurred on the surface of the metal.[25-28] Comparing Fig. 9a and b, Fig. 10a and b, Fig. 11a and b, it can be observed that the benzotriazole derivatives can be adsorbed on the carbon steel type OL37 surface.

The formation of the protective surface film of organic inhibitor on the electrode surface was confirmed by metallurgical research microscope observation on the electrode surface. Fig. 12 shows a few micrographies obtained by us for the following systems OL 37+0.5M H_2SO_4 and after a certain immersion in H_2SO_4 with and without organic inhibitor. As well in the presence of Xppm organic inhibitors the surface becomes more smooth and homogeneous. Analyzing in comparison Figs. 12b, 12c, 12d and 12e-f, it can be observed that, on the surface of micrographies there are the adsorbed films of inhibitor and corrosion products.

Fig. 12 clearly shows the corrosion degree of carbon steel decreases in the presence of organic inhibitors. These films behave like a barrier between corrosive medium and metal surface and as a consequence the corrosion process is inhibited – see in comparison Fig. 12 (a, b, c, d, e and f).[29-31]
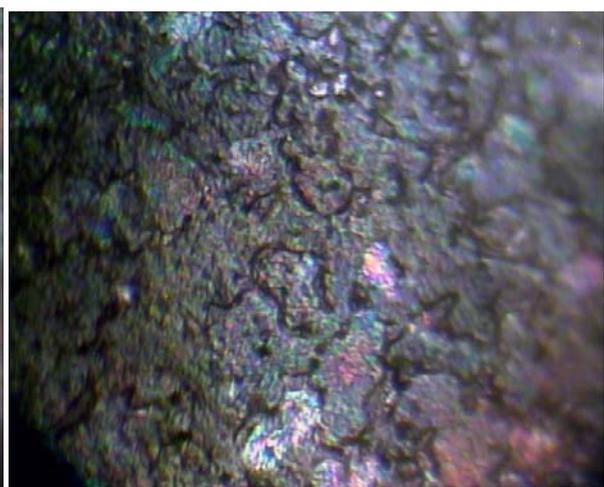
a) OL 37 polished

b) OL37+H₂SO₄

c)

d)
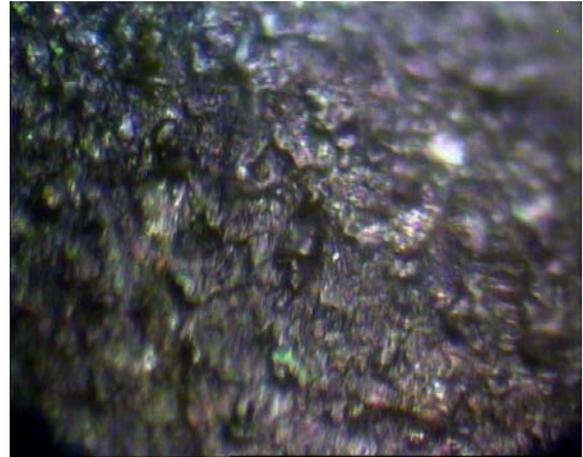
OL37-0.5MH₂SO₄+300ppm and 500ppm 3-amino-5 mercato-1,2,4 benzotriazole
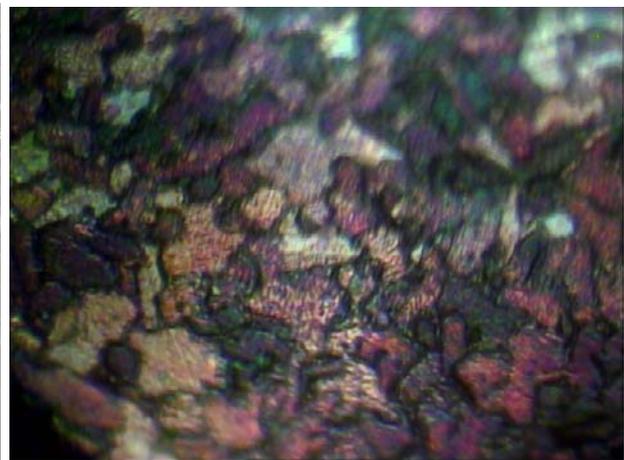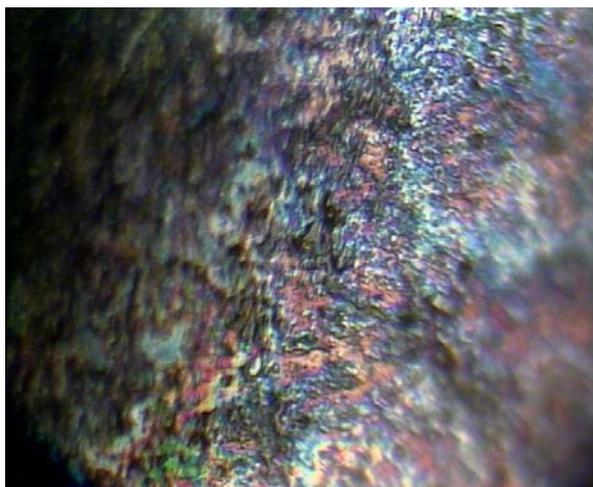
e)

f)

OL37-0.5MH₂SO₄+500ppm 5-Chlorobenzotriazole   1000ppm 1-Hydroxy-benzotriazole

Fig. 12 – Micrographies of the carbon steel in 0.5M H₂SO₄ with organic inhibitor:a) OL 37 polished, b) OL37+0.5M H₂SO₄, c) 300ppm 3-amino-5 mercato-1,2,4 benzotriazole d) 500ppm 3-amino-5 mercato-1,2,4 benzotriazole, e) 500ppm 5-Chlorobenzotriazole and f) 1000ppm 1-Hydroxy-benzotriazole.

CONCLUSIONS

The organic inhibitors 5-Chlorobenzotriazole, 1-Hydroxy-benzotriazole and 3-amino-5 mercato-1,2,4 benzotriazole which was obtained by us has presented a good inhibitory action and a significant efficiency for decreasing of the rate corrosion of the studied carbon steel type OL 37 in 0.5M H_2SO_4.

The organic inhibitors were adsorbed on the carbon steel surface according to a Langmuir isotherm. The inhibition activity analysis of the organic compound was made by assuming that the mechanism of inhibition by organic molecules is chemisorption.

FT-IR spectra revealed very clear that these organic inhibitors were adsorbed on the metal surface.

The adsorption of investigated organic inhibitor follows the Langmuir isotherm and the FT-IR results and it also reveals the adsorption of inhibitor molecule on the metal surface and blocking the active sites.

EIS results are in very good concordance with results obtained by potentiodynamic and potentiostatic methods.

The inhibition efficiency follows the order: 5-Chlorobenzotriazole > 3-amino-5 mercato-1, 2, 4 benzotriazole >1-Hydroxy-benzotriazole

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