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INHIBITION OF MILD STEEL CORROSION IN NUTRAL CHLORIDE MEDIUM BY A MIXTURE OF ZINC PHOSPHATE, AMMONIUM MOLYBDATE AND IMIDAZOLE AND 2-METHYLIMIDAZOLE

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Short Profile

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ABSTRACT:
Mild steel was polarized vs. saturated calomel conductor (SCE) in naturally aerated third NaCl solutions (Blank) containing mixture of inhibitors of different concentrations. The results of weight loss mensuration methodology showed that the quantity of inhibitors increases within the style of mixture with increase the corrosion inhibition. The results of potentiodynamic polarization showed that corrosion current density,icorr,decreases with increasing concentration inhibitors indicating a decrease within the corrosion rate also as an increase within the inhibition potency of soft-cast steel.

KEYWORDS
Chloride, Corrosion Inhibition, Mild steel, Imidazole, 2- methyl imidazole.

I.INTRODUCTION

The inhibition efficiency[1-2] of the formulation consisting of imidazole, 2 – methyl imidazole, molybdate and Zn^{2+} in controlling the corrosion of mild steel in 3% Sodium chloride medium has been evaluated [3] by the weight loss measurement method and potentiodynamic polarization measurements. The obtained results pointed out that the inhibition action [4-10] of a mixture of inhibitors such as imidazole, 2 methyl imidazole, Zn^{2+} and ammonium molybdate. The inhibitive performance of imidazole, 2- methyl imidazole, Zn^{2+} and ammonium molybdate depends on the presence of dissolved oxygen being strongly related to the absorption of Cl- ion on the surface of the electrode [11-14]. The first formulation consisting of 300 PPM imidazole, 300 PPM molybdate and 60 PPM Zn^{2+} has 65% efficiency and the second formulation consisting of 300 PPM, 2 – methyl imidazole, 300 PPM molybdate and 60 PPM Zn^{2+} has 66% efficiency. A suitable mechanism of corrosion inhibition is proposed based on the results obtained from the weight loss method and polarization study.

2. EXPERIMENTAL

2.1 MATERIALS AND METODS

The mild steel specimen was tested in the present study with its dimensions (1cm x 4.5cm x 0.2cm). The composition of the mild steel is as follows (wt%): C = 0.1- 0.2, S = 0.02 – 0.03, Mn = 0.4 – 0.5, P = 0.03 – 0.08 and the rest is Fe. The specimens were degreased by acetone solution for weight loss measurement. The test aqueous solution is 3% Sodium chloride solution (blank solution). Triple distilled water was used for preparing all solutions. The mild steel specimens were immersed in 100 ml of the 3% Sodium chloride solution containing various concentrations of inhibition in the absence and presence of Zn^{2+} (Zinc Phosphate) and molybdate (Ammonium molybdate) for a period of seven days. The weights of the specimens before and after immersion were determined using a wettler balance AE240. In all measurements, abraded electrode was used. Polishing was affected using successively finer grade of emery papers (600 – 1200 grade) and encapsulated with Teflon. Potentiodynamic polarization study was carried out in a three electrode cell assembly connected to a bio analytical system (BAS – 100 A) electrochemical analyzer. The working electrode was a1cm x 1cm mild steel specimen. A 1cm x 1cm platinum foil was used as a counter electrode and saturated calomel electrode was used as a reference.

3. RESULTS AND DISCUSSION

3.1 WEGIHT LOSS MEASURMENT METHOD

The results of weight–loss measurements in the absence of inhibition (blank) and in the presence of various compositions of Imidazole or 2 – methyl imidazole, Ammonium molybdate and Zinc phosphate are given in Table-1. In the absence of any inhibitor the rate of corrosion was 23.41 mdd at the end of seven days. In the presence of 60 PPM of zinc phosphate the maximum inhibition was 15%. In the presence of 200 PPM ammonium molybdate alone the rate of corrosion decreases and the inhibition efficiency was found to be 55%. When the amount of molybdate was increased to 300 PPM the efficiency was found to be 59%. When we consider the inhibition efficiency of imidazole alone, it increases from 23% to 47%. When the amount of imidazole was increased from 100 PPM to 300 PPM.. When we consider the inhibition efficiency of the combination of the above inhibitors in their maximum inhibiting concentrations, the efficiency was forces to be slightly increased compared to when they are used separately. A combination of 300 PPM of imidazole and 60 PPM Zinc phosphate gave 47% inhibition 300 PPM of imidazole and 60 PPM if zinc phosphate exhibited about 65% of inhibition. When 2- methyl imidazole was used the inhibition efficiency increased from 28% to 48% when the concentration of inhibition was increased from 100 PPM to 300 PPM. When we consider the combination of 300 PPM of 2- methyl imidazole and 60 PPM of Zn^{2+} and the efficiency was 66% in the presence of 300 PPM of methyl imidazole, 300 PPM of molybdate and 60 PPM of zinc phosphate.

Table – 1.Results of weight loss measurement of mild steel immersed in 3% Sodium chloride solution for a period of seven days in the presence and the absence of inhibitors.

S.No	Methyl imidazole (PPM)	$M_oO_{4(PPM)}$	Zn^{2+} (PMM)	Corrosion/rate	Inhibition efficiency %
1	0	0	0	23.41	-
2	0	-	30	20.36	13
3	0	-	60	19.79	15
4	-	200	-	10.48	55
5	-	300	-	9.62	59
6	100	-	-	17.96	23
7	200	-	-	13.78	41
8	300	-	-	12.34	47
9	300	-	60	11.54	51
10	300	300	-	9.27	60
11	300	300	60	8.26	65

S.No	2- Methyl imidazole (PPM)	$M_oO_{4(PPM)}$	Zn^{2+} (PMM)	Corrosion/rate	Inhibition efficiency %
1	100	-	-	16.84	28
2	200	-	-	13.32	43
3	300	-	-	12.28	48
4	300	-	60	11.08	53
5	300	300	-	8.92	62
6	300	300	60	7.89	66

3.2 POTENTIODYNAMIC POLARIZATION METHOD

Potentiodynamic polarization was carried out by using a three electrode system. A 1cm x 1cm mild steel specimen was used as working electrode and platinum. Electrode as the counter electrode and saturated calomel electrode as reference electrode. The medium is 3% sodium chloride. The Tafel polarization results are given in Table-2 and figures 1-6. Tafel slopes were measured by drawing tangents to the curve in ± 100mvs region from Ecorr-values. The estimation of Tafel slopes seems to be most subjective due to difficulties in fixing the linear segment[15-17] for the control 'ba' and 'bc' are almost equal which suggests the corrosion reaction to be mixed. The Ecorr is shifted from -390mv for blank to -300mv range which implies the corrosion reaction to be under atomic control[18]. The inhibition efficiency was forced to be around 30 percentages. The atomic corrosion control was in further confirmed by decrease in potential current at Ecorr ± 100 mv. The change in potential current used to confirm the corrosion mechanism [19].

Table – 2 Electrochemical polarization parameter for mild steel in the presence and absence of inhibitors in 3% Sodium chloride solution

S.No	Name of the inhibitor	Amount of Inhibitor in ppm	Ecorr in mv	Tafel slope in mv/dec		Icorr in µA/cm^2	% of Reduction in partial current at Ecorr ±100 mv		% of Inhibition
				Ba	bc		Anodic	Cathodic	
1	Blank		390	88	97	15.85			
2	Zinc Phosphate	30	330	75	106	10.5	45	5	34
		60	330	97	102	10.3	60	2	35
3	Ammonium molybdate	200	325	78	109	6.3	82	32	60
		300	280	96	103	5.6	82	37	65
4	Imidazole	100	320	84	106	14.1	37	52	11
		200	380	91	105	11.2	29	5	29
		300	390	85	106	8.9	72	15	44
5	Zinc Phosphate + Ammonium molybdate + Imidazole	600 + 300 + 300	405	89	110	3.98	84	85	75
6	2-Methyl imidazole	100	325	82	105	13.4	34	49	15
		200	375	73	94	10.6	28	8	33
		300	390	91	109	8.6	66	17	46
7	Zinc Phosphate + Ammonium molybdate + 2- Methyl Imidazole	60 + 300 + 300	89	106	3	92	79	87	75

In the presence of ammonium molybdate the Ecorr was found to be shifted automatically compared to blank. The inhibition efficiency was found to be 65 %. The shift in Ecorr and the decrease in currents also suggest the atomic corrosion control. In the presence of imidazole the corrosion inhibition efficiency was found to increase on increasing the concentration of imidazole from 100 PPM to 300 PPM. The maximum efficiency was found to be 44% in the presence of 320 PPM of imidazole. The change in Ecorr with the change in the concentration of imidazole from 320 to 390 suggests that the corrosion control shifts from anodic to mixed inhibition. However the decrease in partial currents suggests the corrosion control is due to decrease in the anodic corrosion reaction. When a mixture of 60 PPM of zinc phosphate, 300 PPM of ammonium molybdate and 300 PPM imidazole, the inhibition efficiency was forced to be increased to 75%, the Ecorr is -405 mv suggests that corrosion control is mixed and slightly more cathodic control. This was further confirmed by the decrease in partial currents. When imidazole was partial replaced by 2-methyl imidazole a similar trend was observed and there is no significant change in the corrosion efficiency.

Fig.1Potentiodynamic polarization graph for mild steel in the presence and absence of zinc phosphate in 3% NaCl solution

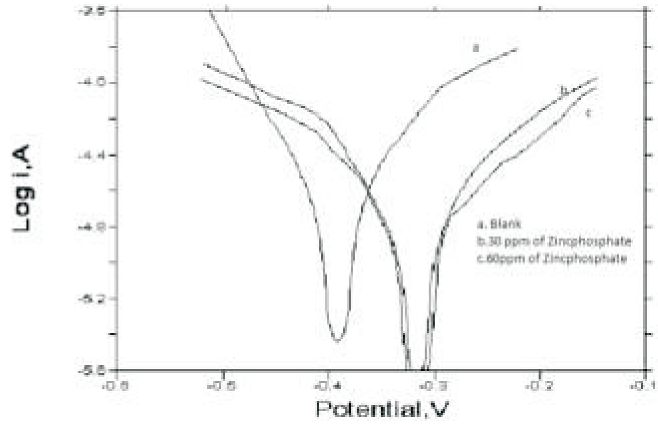


Fig.2Potentiodynamic polarization graph for mild steel in the presence and absence of ammonium molvbdate in 3% NaCl solution.

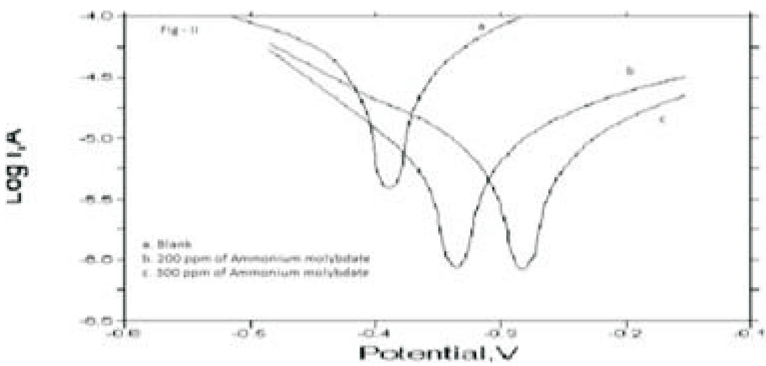


Fig.3Potentiodynamic polarization graph for mild steel in the presence and absence of imidazole in 3% NaCl solution

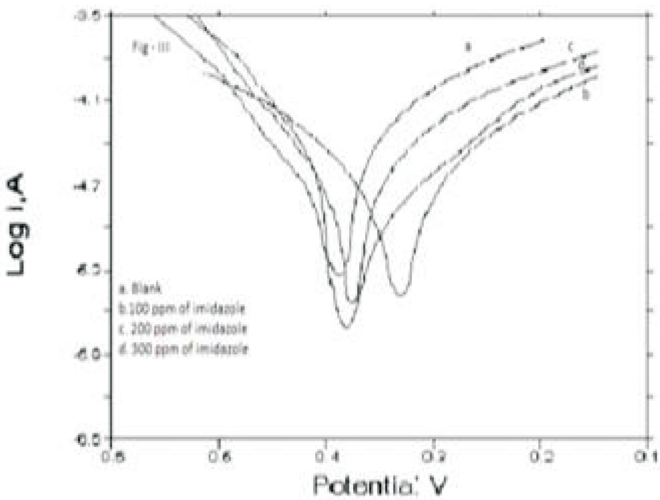


Fig.4 Potentiodynamic polarization graph for mild steel in the presence and absence of zinc phosphate, ammonium molybdate and imidazole in 3% NaCl solution

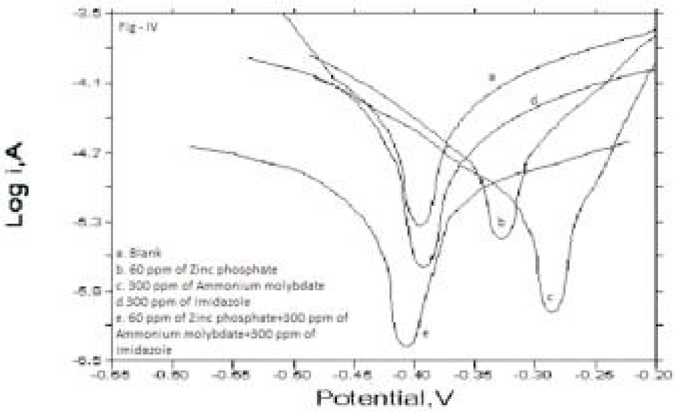


Fig.5 Potentiodynamic polarization graph for mild steel in the presence and absence of 2-methyl imidazole in 3% NaCl solution

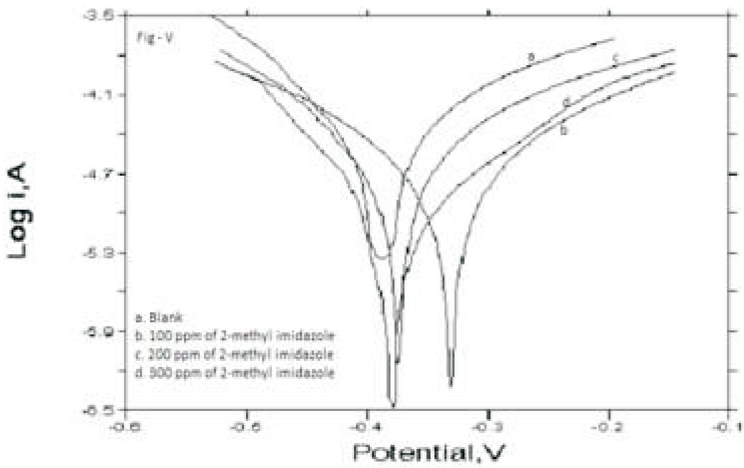
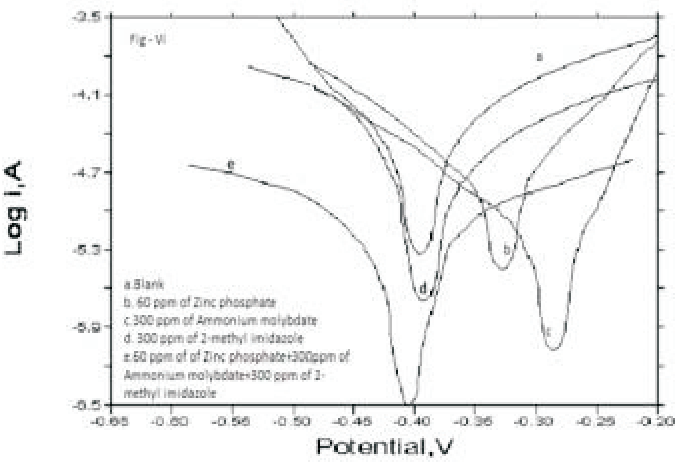


Fig.6 Potentiodynamic polarization graph for mild steel in the presence and absence of zinc phospate, ammonium molybdate and 2-methyl imidazole in 3% NaCl solution



4. CONCLUSIONS

From results of weight loss measurement and Potentiodynamic polarization, we may cover to the following conclusions.

1.Zinc phosphate and ammonium molybdate are controlling the corrosion by controlling the anodic reactions. Imidazole and 2 – methyl imidazole are mixed inhibitors when all the three inhibitors mixed, the mixture was more cathodic than anodic.
2.Comparison of efficiency of imidazole and 2 – methyl imidazole suggests that electrometric effects may not have significant influence in the inhibition efficiency.
3.The mixture of inhibitors is more efficient than their performance separately.

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