CORROSION INHIBITION OF MILD STEEL BY PYRIDINE DERIVATIVES

S.J. Zakvi and G.N. Mehta*

Chemistry Department, Sardar Vallabhbhai Regional College of Engineering and Technology, Surat (Gujarat) 395 007

Corrosion rates of mild steel, in different media were obtained by weight loss, tafel intercept and linear polarisation resistance methods. The results show the order of inhibition efficiency as Pyridine < Lutidine < Collidine. Nicoitinamide exhibited the best performance in comparison to the other compounds studied. The probable mechanisms of the inhibition have been discussed.

Pyridine and its derivatives have been studied by many workers as inhibitors of metallic corrosion [1-6]. Hackerman [4] reported that the increase in electron density on the N-atom of pyridine nucleus due to the introduction of an electron repelling alkyl group enhances the inhibitive effect of such compounds. The position and number of alkyl groups in the pyridine ring also plays an important role in inhibition. The present work deals with the study of corrosion of mild steel (MS) in 0.1 M HCl solutions and the effect of pyridine and its derivatives on the corrosion.

EXPERIMENTAL

Tafel Intercept (TI) and Linear Polarisation Resistance (LPR) techniques, were employed in the galvanostatic mode of polarisation. The preparation and mounting of the working (MS) and auxiliary (Pt) electrodes, the multinecked polarisation cell and other details were essentially the same as reported earlier [7]. The Weight Loss (WL) measurments were made as per the standard procedure [8] using three rectangular 1" x 2" x 0.2" MS coupons for each test. The period of complete immersion in blank experiment was one day. In corrosive media with inhibitors (9.0 g/l each of pyridine (P) 2,6-lutidine (LU) 2,4,6-collidine (COL) and also with nictotinamide (NIC) at 10 to 100 mg/l concentrations), the period of immersion was of five days. All the chemicals were of high purity and the double distilled water was used to prepare the solutions.

RESULTS AND DISCUSSION

The data obtained by the WL, TI and LPR methods for the corrosion of MS in 0.1 M HCl solutions, and with addition of P, LU and COL are presented in Table 1. The cathodic Tafel constants (b_c) obtained from the slopes of straight lines of relevant full polarisation curves in the TI method, gradually increased from 80 mV in the blank acid to finally 150 mV/decade with COL. The anodic Tafel constants (b_a) did not change much, and was averaged to a value of 50 mV/decade; the corrosion and its inhibition was under the cathodic control. The values of a constant 'B' calculated for the term "$(b_a \times b_c)/2.3(b_a + b_c)$" of the Stern-Geary equation (9), using b_a= 50 mV/decade, were between 13.4(blank) to 16.3 mV with the compounds, and these values are satisfactory for the present systems. The value of polarisation resistance (R_p) obtained in the LPR method from the slopes of straight lines of ± 10 mV polarisation from the corrosion potential (E_{corr}), was only 3.30 Ohms in the blank experiments and increased to 31,85.70 and 145 Ohms with P, LU and COL respectively. These compounds have remarkably increased the R_p value showing that resistance to the corrosion attack or inhibition increased by either of the following probable mechanisms. The higher electron density on the N-atom of P might have allowed it to get chemisorbed and to form a thin protective layer on the MS surface. The protonation of the N-atom might have retarded the cathodic reaction $2H^+ + 2e \longrightarrow H_2$. As stated by Hackerman and Ayers [4], the increase in electron density on the N-atom due to introduction of two electron repelling methyl groups in LU enhance the inhibition; the R_p value accordingly increased to 85.70 Ohms. One more methyl group on the N-atom of COL increases the electron density to maximum and hence COL is found more effective as an inhibitor; the R_p value increased to 145 Ohms. The electron density on pyridine ring might have facilitated orientation of the molecules of P, LU and COL horizontally (flatly) chemisorbed and form a loose layer. This inhibitive behaviour was well supported by gradual decrease in values of I_k obtained by extra-

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TABLE 1

EFFECT OF INHIBITORS ON CORROSION OF MILD STELL IN 0.1 M HCl; TEMP. 28 ± 2°C; ANODIC TAFEL CONSTANT, b_a = 50 mV/DECADE, CONSTANT 'B' = $(b_a \times b_c)/2.3(b_a + b_c)$

Inbitor studied (g/l)	Cathodic Tafel Constant b_c (mV/decade)	Constant 'B' (mV)	Linear Polarisation Resistance R_p (Ohms)	Corrosion Current Density (mA/cm^2)		Inhibition Efficiency. IE (%)		
				I_k TI	I_{corr} (B/R_p) LPR	LPR	TI	WL
Blank	80	13.40	3.30	3.60	4.06	--	--	--
Pyridine (9)	112	15.03	31.00	0.35	0.49	89	90	85
2,6 - Lutidine (9)	125	15.53	85.70	0.20	0.18	96	94	90
2,4,6 - Collidine (9)	150	16.30	145.00	0.15	0.11	98	96	92
Nicotinamide								
Blank	125	17.63	3.5	3.2	5.04	--	--	--
0.01	125	17.63	18.5	0.8	0.95	81	75	78
0.03	125	17.63	36.0	0.7	0.49	90	78	82
0.05	125	17.63	154.0	0.7	0.11	91	78	83
0.07	125	17.63	160.0	0.5	0.11	98	84	90
0.1	125	17.63	187.0	0.5	0.09	98	84	90

polation of the cathodic Tafel regions. Though the anodic Tafel regions were not distorted but they might have been influenced by heavy anodic polarisation resulting into the roughened surface due to $Fe \longrightarrow Fe^{2+} + 2e$ reaction. The percentage of inhibition efficiency (IE%) calculated from the values of R_p, I_k and WL are also tabulated. The comparison of these values revealed that P, LU and COL inhibited the corrosion in the following order: P < LU < COL. There was fair agreement of the trend of corrosion inhibition. The value of E_{corr} in the blank acid was -480 mV versus SCE and was shifted towards active direction to -530 mV when these compounds were added. This shift also provided an evidence of the cathodic control. For the same (9.0 g/l) concentration of LU and COL, the values of IE% reported from the WL data in the literature [10] were about 98%, and were higher than those obtained in the present work; the variation might be due to the difference in the MS samples.

The values of R_p and I_{corr} for different concentration of NIC was calculated by dividing the value of 'B' with those of R_p. The value of b_a = 50 and b_c was nearly independent of concentration; the averaged value of b_c = 125 mV/decade. How ever, the initial b_c value in the blank acid was 80 mV/decade. The value of B was calculated using b_a = 50 mV/decade b_c = 125 mV/decade. Even in case of NIC, there was an active shift in the value of E_{corr} very similar to the one stated earlier. This shift and an increase in the b_c value showed that NIC acted as a cathodic inhibitor. The decrease in the value of I_k and I_{corr} and increase in the R_p value, with the increase in concentration of NIC, might be due to formation of a tight and perfect layer of the NIC molecules held together possibly by hydrogen bonding of -CO and $-NH_2$ groups. The best performance of NIC (50 mg/l offered 91% IE) in comparison to the others might be due to flat chemisorbed NIC molecules via either or both the N-atoms forming a tight and perfect layer. The TI method suffered from the limitation in sensitivity (change in the I_k values with the change in concentration of NIC is not appreciable). The values of IE % obtained from LPR and WL data have also shown a general agreement of the inhibitive tendency of NIC. All these compounds could be arranged according to their inhibitive performance in the following order: pyridine < 2,6-lutidine < 2,4,6-collidine < nicotinamide.

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