Asian Journal of Chemistry; Vol. 23, No. 10 (2011), 4454-4456

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in

Investigation of Formazan of Benzaldehyde Compound as Corrosion Inhibitor for Preventing Mild Steel Material in Acidic Medium

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(*Received*: 16 November 2010; *Accepted*: 22 June 2011) AJC-10071

Formazan of benzaldehyde has been prepared as a corrosion inhibitor to control the rate of corrosion. This compound has been investigated as corrosion inhibitor at room temperature for preventing mild steel corrosion in sulphuric acid and hydrochloric acid medium by weight loss method and electrochemical methods. The result showed that the corrosion inhibition efficiency of these compounds was found to vary with different acid concentration. It was also found that the corrosion inhibition behaviour of formazan of benzaldehyde is more in 2 N H_2SO_4 and 2 N HCl. So formazan of benzaldehyde can be used as a good inhibitor for preventing mild steel material in the construction of ship.

Key Words: Mild steel, Corrosion inhibitors, Formazan of benzaldehyde.

INTRODUCTION

The mild steel material corroded in acid medium especially in concentrated mineral acid is a serious problem for some industrial facilities. Several researchers devoted their attention to develop more effective and non-toxic inhibitors to reduce both acid attack and protection aspects[1-6].

The use of organic compounds based on corrosion inhibitors against metal dissolution is often associated with chemical or physical adsorption, involving a variation in the charge of adsorbed substance and a transfer of charge from one phase to other. Special attention has been paid to the effect of electron donating on the atom, electron withdrawing or groups responsible for adsorption mainly depends on steric factors, aromaticity, the structural properties of the organic compounds studied such as the presence of π-electrons and heteroatoms, which induce greater adsorption of the inhibitor molecules on to the surface of mild steel[7-9]. Therefore, in this investigation, the corrosion inhibition of mild steel in 2N HCl and 2N H_2SO_4 solution is studied in the absence and presence of formazan of benzaldehyde for 1 h at room temperature.

The aim of this paper is to evaluate the corrosion inhibition efficiency and analyze the inhibitive mechanism of mild steel corrosion in acid medium using formazan of benzaldehyde as inhibitor. The inhibiting efficiency calculation is conducted using weight loss method and electrochemical impedance spectroscopy (EIS).

EXPERIMENTAL

Sample preparation: According to ASTM method as reported already[10], cold rolled mild steel strips were cut into pieces of 5 cm × 1 cm having the following composition (Table-1).

TABLE-1
ELEMENTAL ANALYSIS

Elements	Chemical composition (%)	Elements	Chemical composition (%)
Iron	99.686	Phosphorus	0.009
Nickel	0.013	Silicon	0.007
Molybdenum	0.015	Manganese	0.196
Chromium	0.043	Carbon	0.017
Sulphur	0.014	–	–

The samples were polished, drilled a hole at one end and numbered by punching. During the study the samples were polished with various grades of emery papers and degreased using trichloroethylene.

Solutions: All the solutions were prepared using NICE brand AR grade chemicals in double distilled water and bubbling purified by nitrogen gas for 0.5 h to carry out de-aeration of the electrolytes. 2N HCl and 2N H_2SO_4 solution was prepared by double distilled water. The corrosion inhibitor solution of 0.1 % formazan benzaldehyde was prepared by dissolving 0.1 g of formazan benzaldehyde in 100 mL of test solution.

And also, 0.02, 0.04, 0.06, 0.08 and 0.10 % solutions of formazan of benzaldehyde were prepared.

Corrosion studies

Weight loss measurement: The weight of specimen were noted and then immersed in test solution containing various concentrations of inhibitors at room temperature. After 1 h in 2N HCl and 2N H_2SO_4, the specimens were removed from test solutions, dried and finally weighed.

Impedance studies: A well polished mild steel electrode was introduced into 100 mL of test solution and allowed to attain a steady potential value A.C. signal of amplitude of 10 mV was applied and the frequency was varied from 10 MHz to 10 KHz using Solartron electrochemical measurement unit (1280B). The real and imaginary parts of the impedance were plotted in Nyquist plots. From the Nyquist plot, the charge transfer resistance (Rct) and double layer capacitance (Cdl) values were calculated[11,12].

The charge transfer resistance values were obtained from the plots of Z' *vs.* Z". The values of (R_s + R_{ct}) correspond to the point where the plots cuts Z' axis at low frequency and R_s corresponds to the point where the plot cuts Z' axis at high frequency. The difference between R_{ct} and R_s values give the charge transfer resistance (R_{ct}) values.

The inhibition efficiencies (IE) were obtained from R_{ct} values as follows:

$$IE\ \% = \frac{R_{ct(i)} - R_{ct}}{R_{ct(i)}} \times 100$$

where R_{ct} = Charge transfer resistance in the absence of inhibitor; $R_{ct\,(i)}$ = Charge transfer resistance in the presence of inhibitor.

RESULTS AND DISCUSSION

Weight loss method: The corrosion behaviour of mild steel in 2N H_2SO_4 and 2N HCl with formazan of benzaldehyde was given in Fig. 1, which was studied by weight loss method for 1 h at room temperatures From the graph, it was observed that the weight loss of mild steel in the acid decreases with increasing concentration of additives, suggesting that the additives are corrosion inhibitor for mild steel in 2N HCl and 2N H_2SO_4. From the data of weight loss method, the corrosion rate (CR) was calculated using the equation:

$$CR = (87.6 \times W) / (D \times A \times T)$$

where W, D, A and T are weight lose (in mg), density of mild steel (7.86 g/cc), area of the specimen in cm square and exposure time in hours, respectively.

Similarly, inhibition efficiency (IE) was calculated using the equation:

$$IE\ (\%) = [(W_o - W_i)/W_o] \times 100$$

where W_0 and W_i are the values of the weight loss (g) of mild steel in the absence and presence of inhibitor, respectively. The values of corrosion rate and inhibition efficiency in absence and presence of difference concentration of inhibitor used in 2N HCl and 2N H_2SO_4 solution at room temperature for 1 h were given in Table-2.

TABLE-2
CORROSION INHIBITION BEHAVIOUR OF MILD STEEL IN 2N HCl AND 2N H_2SO_4 SOLUTION IN ABSENCE AND PRESENCE OF FORMAZAN OF BENZALDEHYDE IS STUDIED BY WEIGHT LOSS MEASUREMENT

Corrosion inhibitor	Conc. of inhibitor (%)	Corrosion rate (mm/y)		Inhibitor efficiency	
		2N HCl	2N H_2SO_4	2N HCl	2N H_2SO_4
Formazan of benzaldehyde (FB)	Blank	780.0401	1739.8501	–	–
	0.02	307.8255	115.5743	60.53	92.59
	0.04	289.7702	108.2182	62.85	93.78
	0.06	242.1813	91.5001	68.95	94.74
	0.08	193.4774	56.1708	75.19	96.77
	0.10	160.3775	55.5230	89.43	96.80

From Table-2, it is clear that the corrosion rate was decreased with increasing concentration of inhibitor and inhibition efficiency increased with increasing the concentration of the inhibitor. In addition, the maximum corrosion inhibition efficiency of formazan of benzaldehyde was 89.43 % at 2N HCl acid and 96.80 % at 2N H_2SO_4, respectively at 0.10 % solution of inhibitor for 1 h at room temperature. It was also suggested that the inhibitor was best inhibitor in preventing the mild steel corrosion in 2N HCl and 2N H_2SO_4. But when comparing with acids the inhibitor efficiency was more in 2N H_2SO_4 than 2N HCl.

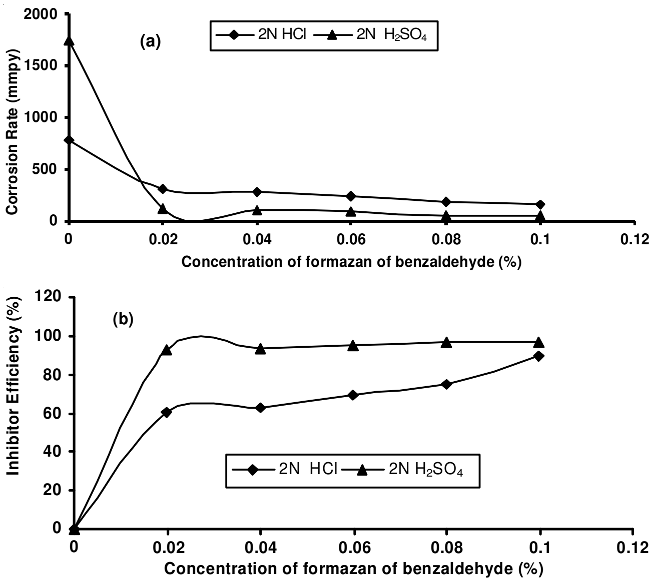

Fig. 1. (a) Comparison of corrosion rate (CR) with concentration of formazan benzaldehyde (in %) in 2N HCl and 2N H_2SO_4 solution at 1 h at room temperature, (b) Comparison of inhibition efficiency (IE) with concentration of formazan of benzaldehyde (%) in 2N HCl and 2N H_2SO_4 solution at 1 h at room temperature

Electrochemical impedance spectroscopy results: Impedance diagram (Nyquist plot) obtained for mild steel in 2N HCl has been depicted in Fig. 2 and 2N H_2SO_4 in the presence of various concentrations of the inhibitor is depicted in Fig. 3. They are prefect semicircles and this was attributed to charge transfer reaction. Impedance parameters derived from Nyquist plot are tabulated in Table-3. It can be seen that as the concentration of inhibitor increases, Cdl value decrease. Decrease in Cdl, which can result from an increase in thickness

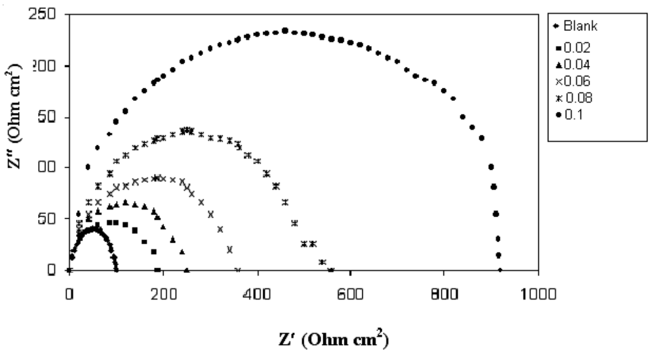

Fig. 2. Nyquist plots for mild steel in 2 N HCl with formazan of benzaldehyde

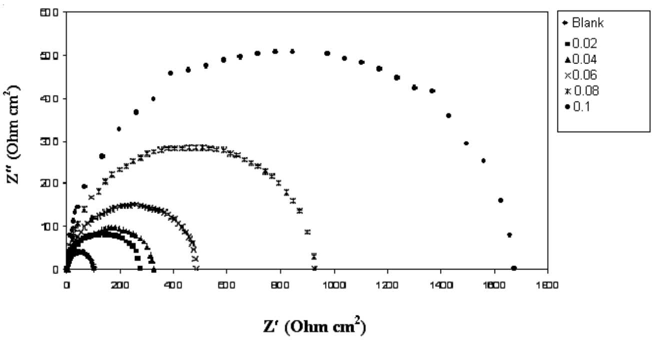

Fig. 3. Nyquist plots for mild steel in 2N H_2SO_4 with formazan of benzaldehyde

TABLE-3
IMPEDANCE PARAMETERS FOR THE CORROSION OF MILD STEEL IN 2N HCl AND 2N H_2SO_4 CONTAINING DIFFERENT CONCENTRATION OF FORMAZAN OF BENZALDEHYDE

Conc. of inhibitor (%)	R_{ct} (ohm cm^2)		C_{dl} (μF/cm^2)		Inhibitor efficiency (%)	
	2N HCl	2N H_2SO_4	2N HCl	2N H_2SO_4	2N HCl	2N H_2SO_4
Blank	100.12	100.12	13.20	13.20	–	–
0.02	188.97	270.92	10.47	8.00	47.02	63.04
0.04	250.62	325.62	8.45	6.99	60.05	69.25
0.06	358.87	480.12	6.24	5.11	72.10	79.15
0.08	558.57	922.14	4.16	2.73	82.21	89.14
0.10	920.42	1672.57	3.91	1.56	89.12	94.01

of electrical double layer, suggests that the inhibitor molecules function by adsorption at the metal-solution interface.

Conclusion

The formazan benzaldehyde was found to be effective inhibitor in the acidic medium giving upto 89.43 in 2N HCl and 96.80 in 2N H_2SO_4. The inhibition efficiency increased with increase in concentration of inhibitors for 0.02 to 0.10 % at 1 h at room temperature. From the comparative studies of weight loss method, it was concluded that the inhibitor efficiency is better in 2N H_2SO_4 than 2N HCl. Weight loss data were confirmed by impedance method. The rate of corrosion in mild steel in sulphuric acid was higher than that of hydrochloric acid because of sulphuric acid is a dibasic acid, so it stimulated the corrosion rate of mild steel.

ACKNOWLEDGEMENTS

The authors are thankful to Mahendra Engineering College and AMET University to carry out the present work.

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