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Action of 2-Mercaptobenzothiazole as Corrosion Inhibitor for Mild Steel in Hydrochloric Acid Solution

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Abstract: The effect of 2-Mercaptobenzothiazole on the corrosion rate of mild steel in 1.0M hydrochloric acid solution has been studied. The protection efficiency obtained by weight loss method at 20,30 and 40°C temperature using 100, 200 and 400ppm concentrations of the inhibitor. The investigated results showed that the inhibition efficiency increases with the increase in concentration of the inhibitor and decreases with the increase in temperature. The behaviour was found to be in good agreement with Scanning Electron Micrographs (SEM) analysis. The SEM analysis indicated that the metal surface was in a better condition in the presence of the Inhibitor as compared to the specimen exposed in the absence of the inhibitor. 2-Mercaptobenzothiazole acted as a very good corrosion inhibitor for mild steel in acidic medium.
Keywords: 2-Mercaptobenzothiazole, SEM, Corrosion, Inhibitor, Mild Steel.

I. INTRODUCTION

Mild steel is used in a wide range of industrial applications due to its low cost, toughness, good ductility and provide material properties that are acceptable for many applications [1]. However, using acid solution during pickling, industrial cleaning and descaling leads to severe corrosion of mild steel [2,3]. There are possibilities to reduce the corrosion rate to a safe level by adding inhibitors to the acid solutions. Inhibitors hinder corrosion reactions either by reducing the possibility. of corrosion occurrence or by reducing the rate of attack or by both. It has been observed that compounds possessing nitrogen and sulphur as active centres are easily and quickly adsorbed on the metal surface forming a protective layer on the surface of metal and have been extensively used for the inhibition of steel corrosion by acids [4-8]. Every and Riggs [9] reported that compounds containing nitrogen and sulphur both are often better inhibitors as compared to the compounds containing only nitrogen or sulphur.
Therefore, the aim of the present work was to study the inhibition action of 2-Mercaptobenzothiazole which contain both nitrogen and sulphur atoms for the corrosion inhibition of mild steel in 1.0M hydrochloric acid solution using weight loss method and Scanning Electron micrographs analysis of mild steel specimens in the presence and absence of the Inhibitor at 20, 30 and 40°C temperature.

II. EXPERIMENTAL

A. *Materials Preparation*

The mild steel sheet used for the present investigation had the following composition

Element	C	O	Si	P	S	Cr	Ni	Fe
% (w/w)	0.25	1.10	0.77	0.07	0.05	0.03	0.05	Balance

From the sheet, rectangular specimens of mild steel were cut into 2 x 4 cm^2 size. All the chemicals used were of AR grade, and double distilled water was used for preparing solutions.

B. *Weight Loss Method*

For weight loss experiments, specimens of mild steel of size 2 x 4 cm^2 were used. All the specimens were polished successively with different grades of emery papers and were then thoroughly cleaned with double distilled water and acetone. Specimens were then dried and stored in a desiccator over silica gel. Weight loss experiments were performed using0,100 ,200 and 400ppm concentrations of 2-Mercaptobenzothiazole in 1.0M hydrochloric acid solution at 20, 30 and 40°C temperatures for 12 hours of exposure time. The specimens in uninhibited and inhibited solutions were weighed using electronic balance before and after exposure to calculate the loss in weight due to corrosion. The corrosion rate and percentage inhibition efficiency were then calculated using the following relations.

$$\text{Corrosion Rate(mpy)} = \frac{534\,W}{DAT}$$

where,

W= Weight loss in mg
D= Density of specimen in gcm^{-3}
A= Area of specimen in square inch
T= Exposure time in hours

and $$E = \left(\frac{A-B}{A}\right) \times 100$$

where, E= Percentage inhibition efficiency
A= Weight loss in uninhibited system
B= Weight loss in inhibited system

C. Surface Morphology Study

To study the morphology of the corroded surface of the specimens, Scanning Electron Microscope (Model JSM-840, JEOL Make) was used. The specimens were exposed to 1.0M hydrochloric acid solution for 12 hours in the absence and presence of 200 and 400 ppm of the inhibitor. All the micrographs of corroded specimens were taken at a magnification of 800.

III. RESULTS AND DISCUSSION

The corrosion rate and percentage inhibition efficiency data of mild steel containing 1.0M hydrochloric acid solution in the absence and presence of 100, 200 and 400pm concentrations of 2-Mercaptobenzothiazole at 20, 30 and 40°C temperatures were calculated using the weight loss method. The results obtained are recorded in Table 1.

Table 1
Percentage Inhibition efficiency of 2-Mercaptobenzothiazole towards the corrosion of mild steel in 1.0 M hydrochloric acid solution by weight loss method (Exposure Time = 12 hours)

Concentration of Inhibitor (ppm)	Temperature (^{0}C)	Weight Loss (mg)	Corrosion Rate(mpy)	Inhibition Efficiency (%)
Nil	20	49.70	227.20	----
	30	87.31	399.14	----
	40	127.22	581.50	----
100	20	11.21	51.26	83.43
200	20	7.54	34.50	90.81
400	20	4.62	21.12	96.69
100	30	24.54	112.22	77.87
200	30	19.68	89.98	83.45
400	30	14.07	64.35	89.86
100	40	45.24	206.81	70.43
200	40	36.01	164.66	77.68
400	40	27.89	127.53	84.06

From the results recorded in Table 1 it is observed that 2-Mercaptobenzothiazole acted as an efficient corrosion inhibitor for mild steel in 1.0M hydrochloric and solution. The inhibition efficiency increases gradually with an increase in the concentration of 2-Mercaptobenzothiazole from 100 to 400 ppm and decreases with the rise of temperature from 20 to 40°C. A maximum inhibition efficiency of 96.69% was obtained at 400 ppm concentration of 2-Mercaptobenzothiazole in 1.0M hydrochloric acid solution at a temperature of 20°C. Figs 1, 2 and 3 show the scanning electron micrographs (SEM) of mild steel specimens exposed to 1.0M hydrochloric and solution for 12 hours in absence and presence of 200 and 400 ppm concentration of 2-Mercaptobenzothiazole respectively. It is indicated from micrographs that in presence of 2-Mercaptobenzothiazole, the surface of mild steel is in a better condition than that in the absence of the inhibitor.

Also with the increase in the concentration of the inhibitor from 200 to 400 ppm the condition of the surface is further improved which indicated that the efficiency of the inhibitor is lesser at lower concentrations of the inhibitor. Quite smooth micrographs in presence of inhibitor and the absence of either pitting or preferential dissolution suggested that a uniform protective layer of 2-Mercaptobenzothiazole is present on the surface of mild steel.

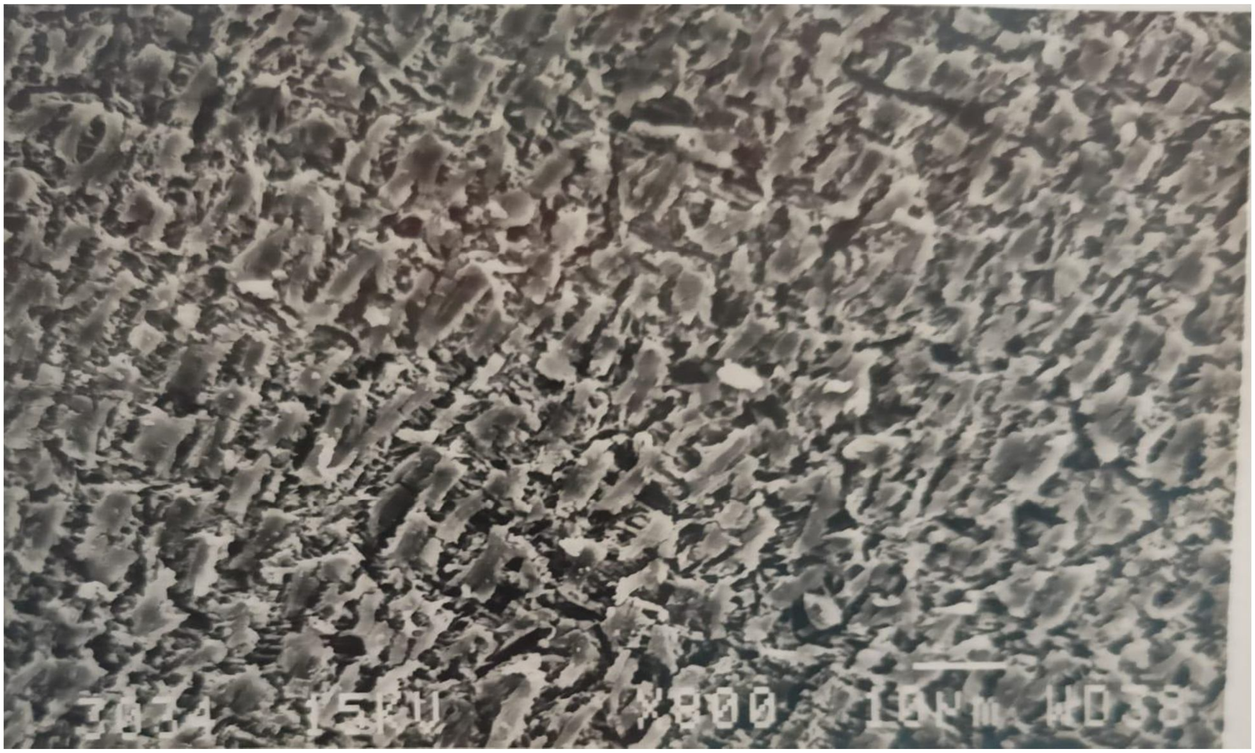

Fig. 1 SEM micrograph of mild steel exposed to 1.0M hydrochloric acid solution for 12 hours (x 800).

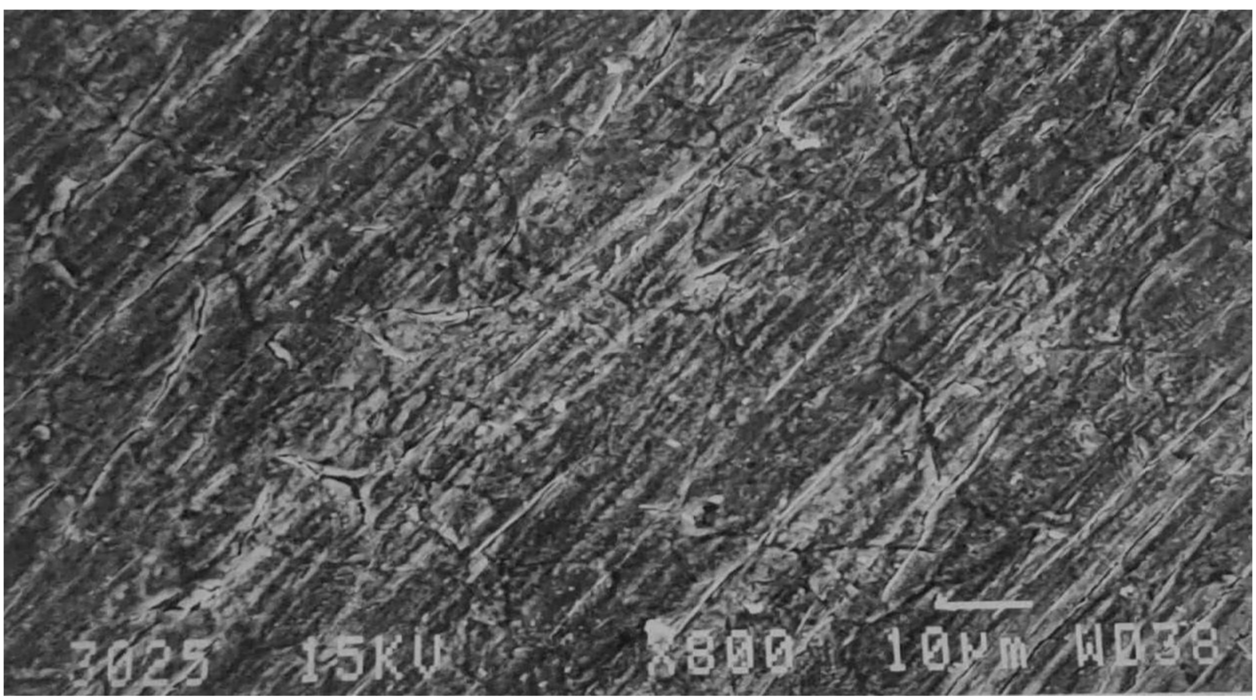

Fig. 2 SEM micrograph of mild steel surface exposed to 1.0M hydrochloric acid solution in presence of 200 ppm of 2-Mercaptobenzothiazole for 12 hours (x 800).

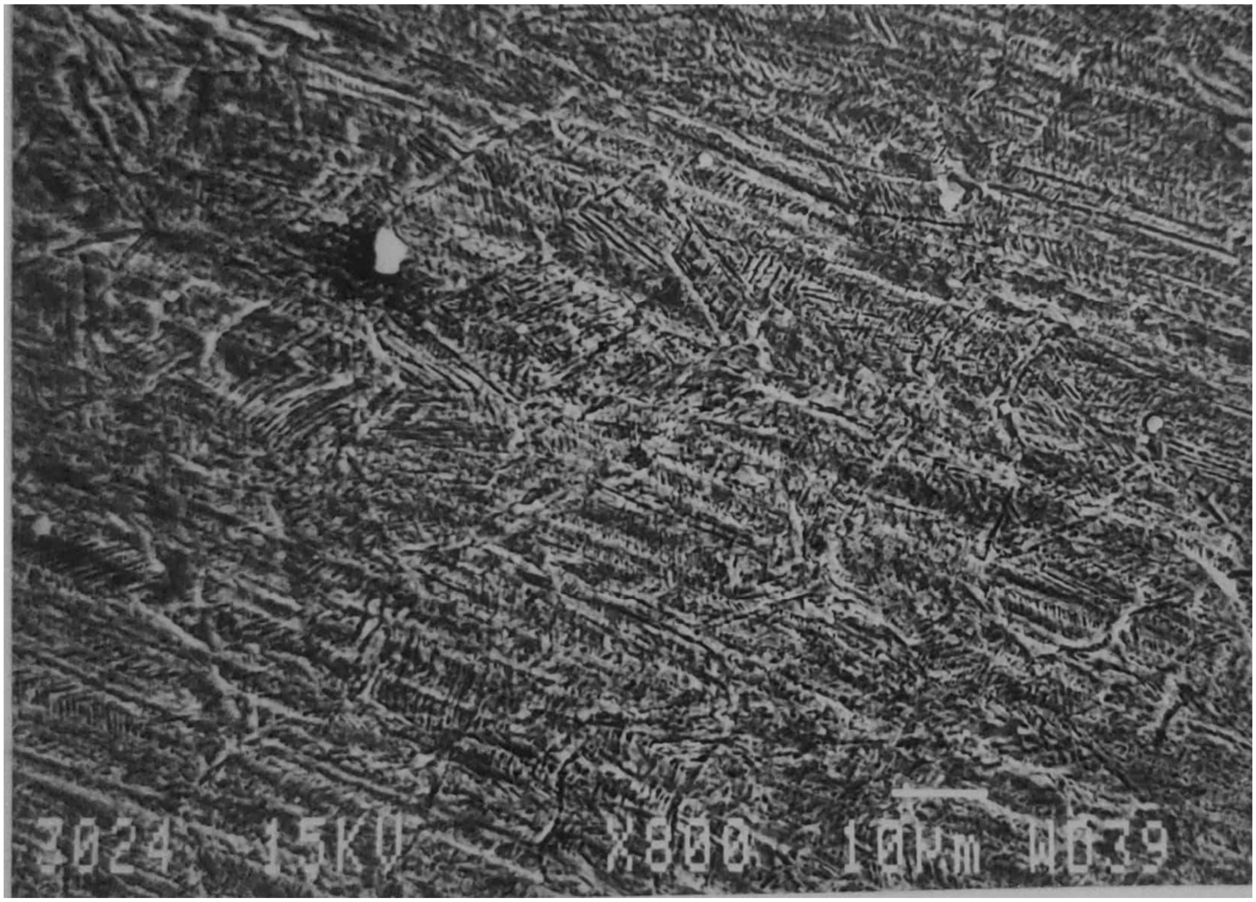

Fig. 3 SEM micrograph of mild steel surface exposed to 1.0M hydrochloric acid solution in presence of 400 ppm of 2-Mercaptobenzothiazole for 12 hours (x 800).

IV. CONCLUSION

2-Mercaptobenzothiazole used in the present study as a corrosion inhibitor shows a significant effect on the corrosion of mild steel in hydrochloric and solution. The inhibition efficiency increases with an increase in the concentration of the inhibitor and decreases with increasing temperature. Maximum inhibition of 96.69% is observed at 20°C and 400ppm concentration of the inhibitor. The inhibition is due to the adsorption of the inhibitor molecules on the mild steel surface.

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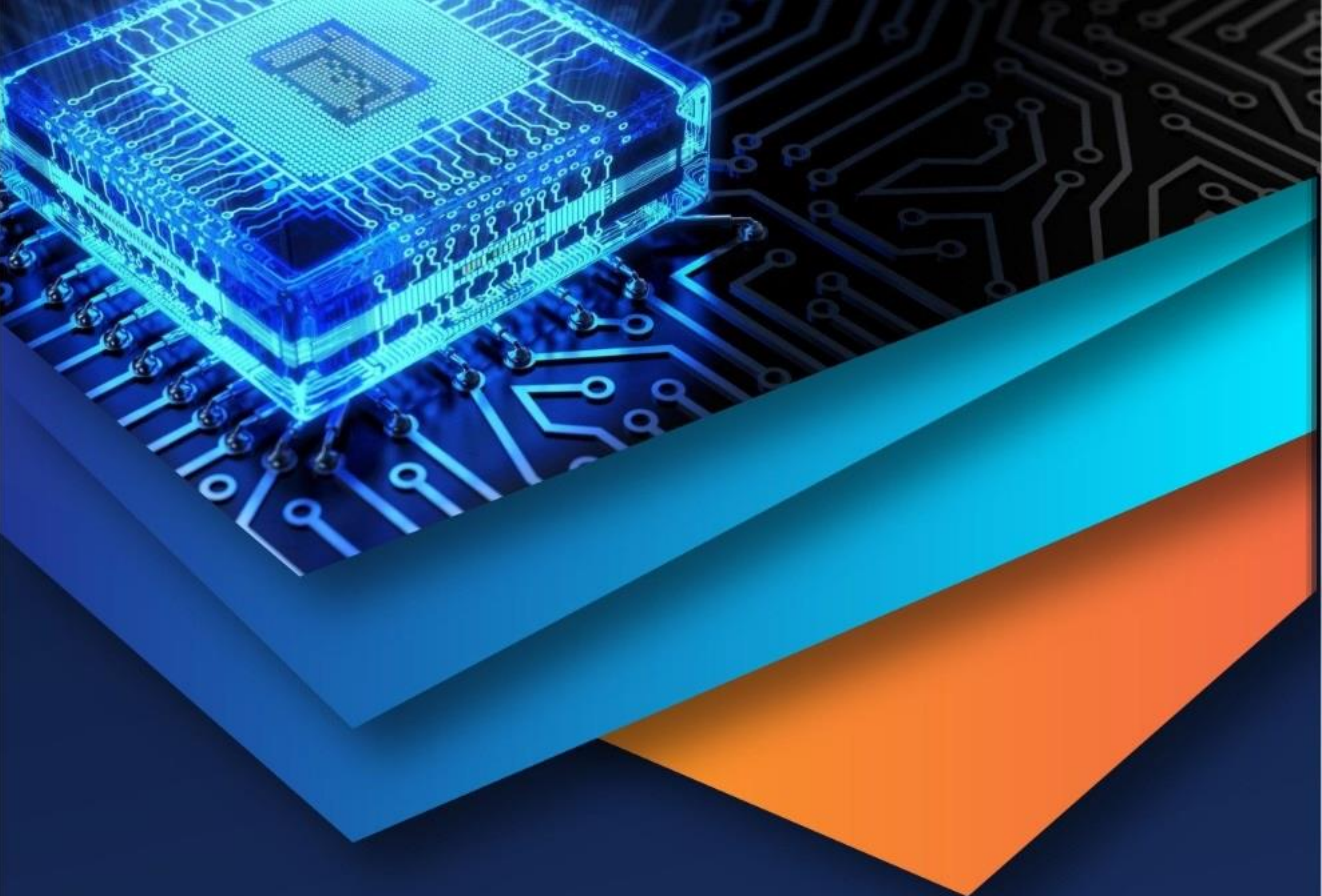

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