Mössbauer Spectroscopic Study of Effect of Ascorbic Acid on Corrosion of Mild Steel in 1.0M Sodium Sulphate Solution

Dr. Kashyap Dhoot[1,*]
[1,*]Department of Physics, JNVU, Jodhpur, Rajasthan, India

A systematic study of the ascorbic acid on the corrosion of mild steel in 1.0M solution of Sodium Sulphate (controlsSolution) has been carried out using Mössbauer Spectroscopy. It is observed that the presence of ascorbic acid of strength ≥ 0.1M in corroding media (1.0M solution of sodium sulphate) influences the formation of usual corrosion species like β, γ-FeOOH and Ferrihydrite. It also retards the rate of rust formation.

Keywords: Ascorbic acid, Mössbauer Spectroscopy,Corrosion species.

1. INTRODUCTION

The reducing agent can suppress the rate of corrosion. The rate of corrosion of mild steel can be controlled by imposing suitable condition which hinders the formation of Fe^{2+} ions. The temperature, pH, initial concentration of ferrous ions and the presence of reducing agents proved to be of help in controlling the corrosion process.

The efficacy of some of the reducing agents in inhibition of corrosion of mild steel was reported by Iovchev [1] and Iovchev et al. [2]. Nigam et al. [3] reported that ascorbic acid behaves as a corrosion inhibitor when it is present in brackish water (corrosive media) having concentration greater than 0.05M. Recently Natalya et al. [4] reported corrosion inhibition of carbon steel in acidic environment and Adriana et al. [5] have reported corrosion inhibition of carbon steel in hydrochloric acid.

The aim of present investigation is to study the corrosion of mild steel by 1M Na_2SO_4 solution in presence of different strength of ascorbic acid (which is mild reducing agent) and to understand its role in the process of corrosion.

Na_2SO_4 solution was chosen because many vital and scarce resources of this region (Jodhpur Western Rajasthan) have high salinity and therefore are very corrosive to mild steel. Mössbauer Spectroscopy was used because it is suitable to identify chemical state of iron.

2. EXPERIMENTAL

All the chemicals used were of Analytical Reagent Grade. Mild Steel Plates of size 2.5X2.5X0.2 cm^3 were first mechanically polished and degreased by acetone and benzene prior to use. The mild steel plates were immersed in 1M Na_2SO_4 solution for 10, 20 and 30 days separately. For evaluation of the influence of ascorbic acid on corrosion process of mild steel the plates were also immersed in solution of Na_2SO_4 containing 0.01, 0.1 and 1.0M concentration of ascorbic acid. For each concentration samples were run independently for 30 and 60 days. The loss of water (in control and inhibitive solution) due to evaporation was compensated by addition of deionized water. Solutions were kept in stagnant condition. After stipulated time samples were dried at room temperature and finally rust was scrapped from the surface for Mössbauer Spectroscopic investigations. Instrumental and Experimental setup is described by A.N. Nigam et al. [6]. Mössbauer spectra were recorded in transmission mode at Room Temperature. Isomer shift (IS) was determined with respect to centroid of standard α-foil (25μm).

3. RESULT AND DISCUSSION

The Mössbauer spectra(s) obtained for rust of mild steel due to exposure in 1.0M Na_2SO_4 solutions and inhibitor solution for different time are shown in Figure 1 and 2(a), 2(b), 2(c) respectively. Mössbauer Parameters obtained for these spectra(s) are given in Table 1 and 2 respectively.

Table 1: Mössbauer parameters for Rust due to 1M Na_2SO_4 solution (Control solution).

Exposure Time (days)	Doublet	QS mm/s	IS mm/s	LW	A %	Species
10	AA'	0.62	0.33	0.43	87.0	Fe^{3+}
10	BB'	1.21	0.38	0.30	13.0	Fe^{3+}
20	AA'	0.56	0.35	0.37	84.0	Fe^{3+}
20	BB'	1.05	0.34	0.30	16.0	Fe^{3+}
30	AA'	0.6	0.35	0.43	87.0	Fe^{3+}
30	BB'	1.19	0.35	0.30	13.0	Fe^{3+}

Table 2: Mössbauer parameters of Rust of mild Steel due to 1M Na_2SO_4 solution containing Ascorbic acid (Inhibitive solution).

Concentration of Ascorbic Acid	Doublet	QS mm/s	IS	LW	A %	Species
	Exposure Time 30 Days					
0.01M	AA'	0.67	0.49	0.41	81.0	β,γ-FeOOH
	BB'	1.12	0.49	0.3	19.0	Ferrihydrite
0.1M	BB'	0.87	0.35	0.46	29.0	Ferrihydrite
	DD'	1.71	1.17	0.3	71.0	?
1.0M	DD'	1.72	1.17	0.35	100	?
	Exposure Time 60 Days					
0.01M	AA'	0.61	0.35	0.36	58	β,γ-FeOOH
	BB'	1.02	0.36	0.38	42	Ferrihydrite
0.1M	AA'	0.65	0.17	0.30	10	β,γ-FeOOH
	DD'	1.72	1.16	0.30	90	?
1.0M	DD'	1.70	1.18	0.30	100	?
	Exposure Time 90 Days					
1.0M	DD'	1.70	1.17	0.30	100	?

?- some Fe (II) complex of Ascorbic acid.

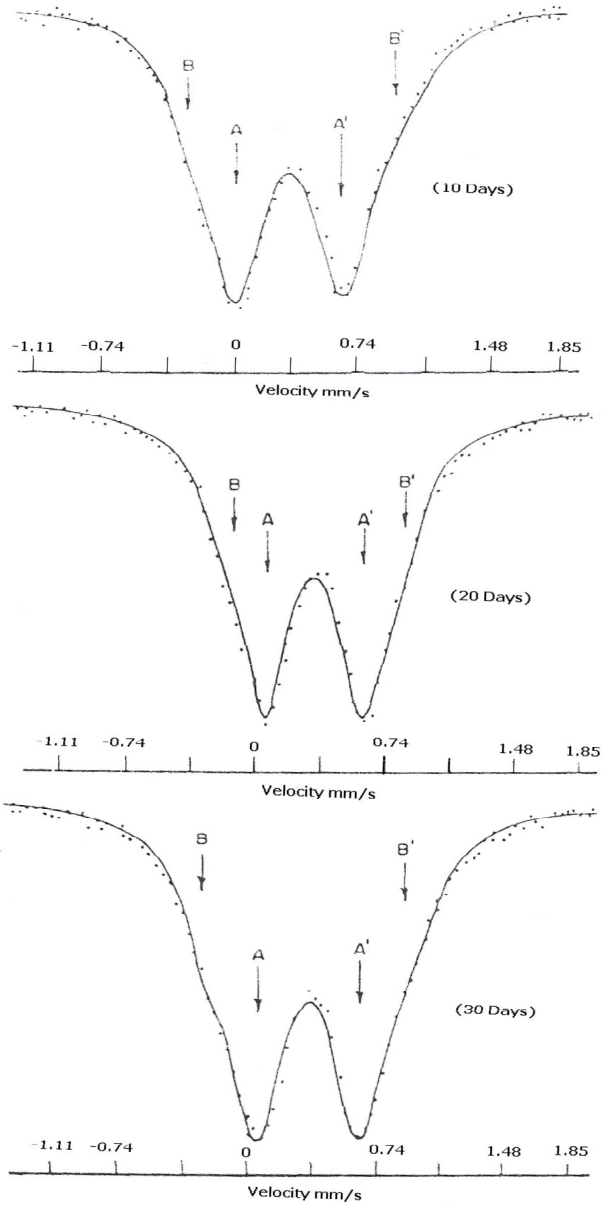

Fig. 1: Mössbauer Spectra(s) of Rust due to exposure of mild Steel in 1M Na_2SO_4 solution.

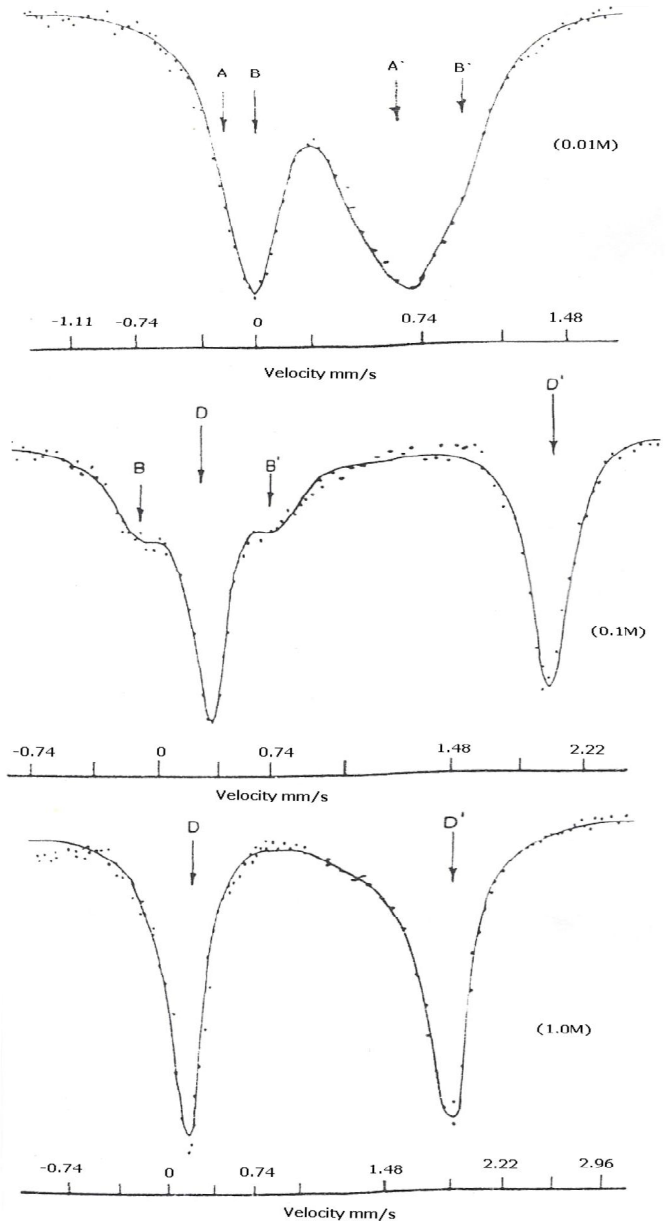

Fig. 2(a): Mössbauer Spectra(s) of rust due to Exposure of Mild Steel in 1M Na_2SO_4 Solution containing Ascorbic Acid of different concentration (Exposure time 30 days).

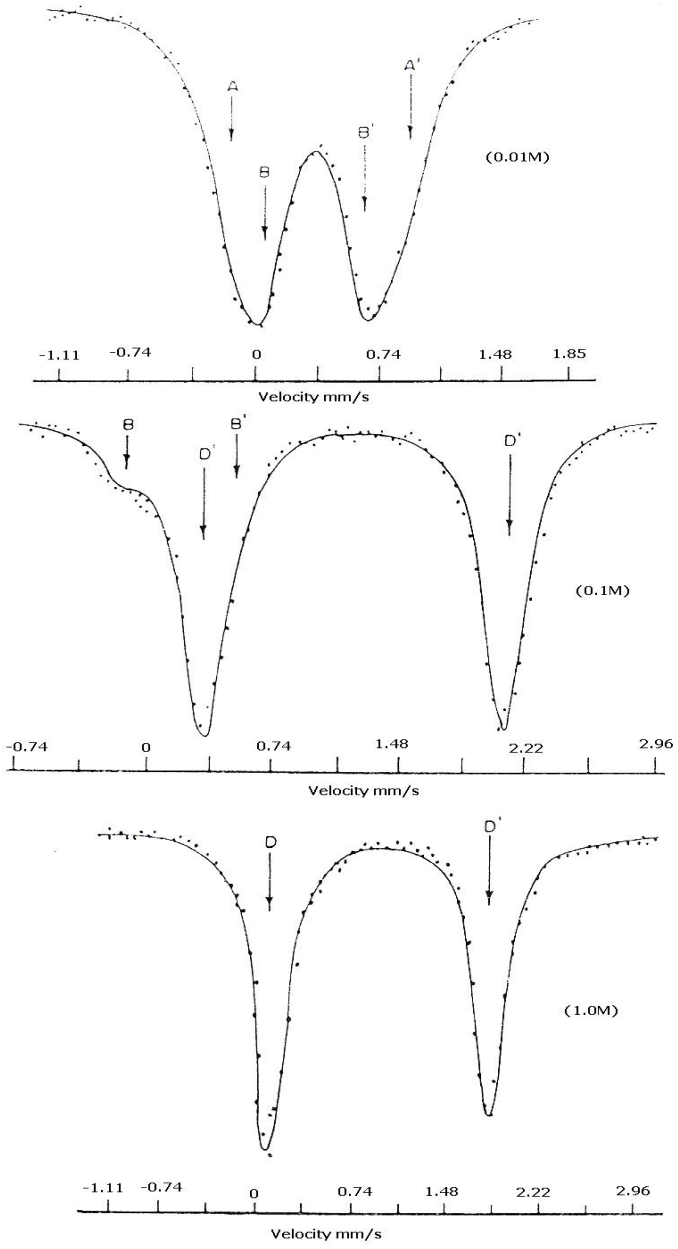

Fig. 2(b): Mössbauer Spectra(s) of rust due to Exposure of Mild Steel in 1M Na_2SO_4 Solution containing Ascorbic Acid of different concentration (Exposure time 60 days).

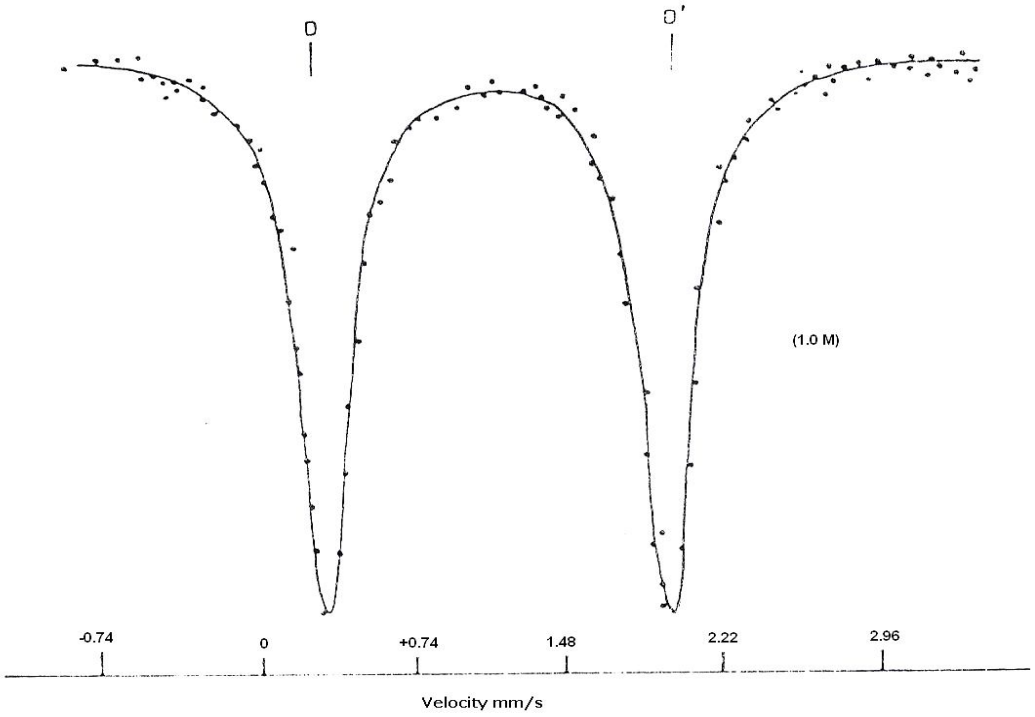

Fig. 2(c) Mössbauer Spectra(s) of rust due to Exposure of Mild Steel in 1M Na_2SO_4 Solution containing Ascorbic Acid of different concentration (Exposure time 90 days).

From Table 1 it can be seen that the exposure of mild steel plates in Na_2SO_4 solution for 10, 20, 30 days has yielded usual corrosion species like Ferrihydrite and γ-FeOOH. In case of inhibitor solution Mössbauer spectra(s) showed a similar trend as obtained by Nigam et al. [3]. Immersion of mild steel plate in Na_2SO_4 solution containing 0.01M ascorbic acid have shown the usual corrosion products like Ferrihydrite and γ-FeOOH even after 30 and 60 days exposure. The only difference is that the doublet corresponding to Ferrihydrite is more intense in case of inhibitive solution as compared to control solution which indicates that the presence of 0.01M ascorbic acid which has not allowed conversion of Ferrihydrite into γ-FeOOH. The most significant result of this study is that when 1M Na_2SO_4 solution containing ascorbic acid around 0.1 M or higher concentration a typical Fe^{2+} appeared having QS 1.71 to 1.74 and IS 1.20 to 1.21 mm/s which was also observed by Nigam et al. [3]. These values of QS and IS indicates the presence of high spin Ferrous Fe^{2+} in a distorted environment. Intensity of this doublet (DD') increases with concentration of Ascorbic Acid at the cost of Fe^{2+} and Fe^{3+} corrosion species. On the basis of these observations it is suggested that this doublet is probably due to Fe(II) complex with ascorbic acid. QS and IS values of this component show a little variation suggesting that the corresponding species has definite structure. The presence of this component even after 90 days of exposure also suggests

that it must be stable. The identification of this component has not been tried. Its nature will not alter the conclusion, that the presence of ascorbic acid drastically affects the corrosion process and suppresses the formation of usual corrosion species.

REFERENCES

[1] M. Iovchev; "Aluminium—thiourea inhibitors of mild steel corrosion in high specific salinity water. Compatibility with calcium, magnesium and ferrous ions at various temperatures", Desalination, Vol. 52(3), pp. 285-293,1985.

[2] M. Iovchev and I. Bankovaka; "Aluminium-thiourea inhibitors of mild steel corrosion in high specific salinity water. Compatibility with some reducing agents at various temperatures", Desalination, Vol. 42(2), pp. 221-228, 1982.

[3] A.N. Nigam, R.P. Tripathi, M.L. Jangid, K. Dhoot and M.P. Chacharkar; "The influence of ascorbic acid on the corrosion of mild steel", Journal of Corrosion Science, Vol. 30(2-3), pp. 201-207, 1990.

[4] V. Likhanova Natalya, Olivares-Xomet Octavio, Guzmán-Lucero Diego et al.; "Corrosion Inhibition of Carbon Steel in Acidic Environment by Imidazolium Ionic Liquids Containing VinylHexafluorophosphate as Anion", Int. J. Electrochem. Sci., Vol. 6, pp. 4514-4536, 2011.

[5] Adriana Patru Samide, Ion Bibicu, Mihaela Agiu and Mircea Predaa, "Mössbauer spectroscopy study on the corrosion inhibition of carbon steel in hydrochloric acid solution", Materials Letters, Vol. 62(2), pp. 320-322, 2008.

[6] A.N. Nigam, R.P. Tripathi, M.L. Jangid and M.P. Chacharkar; "Studies on corrosion of mild steel by water using Mössbauer spectroscopy", J. RADIOANAL. Nucl. Chem. letters, Vol. 117(4), pp. 243-254, 1987.