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# Inhibition of Mannich Base on the Corrosion of Mild Steel in Acid - a Review

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**Abstract:** *Mannich base was synthesized and characterized and it was tested as a corrosion inhibitor for mild steel in acid solution using weight loss method. The inhibition efficiency was increased with respect to concentration of inhibitor and decreased with respect to temperature. Various thermodynamic parameters were also determined to investigate the mechanism of corrosion inhibition. The results obtained from weight loss and electrochemical methods are in good agreements.*

**Keywords:** *Mannich base, mild steel, weight loss.*

## 1. INTRODUCTION

Mild steel finds a variety of applications industrially, in mechanical and structural purposes like bridge work, buildings, boiler plates, steam engine parts and automobiles. There are various uses of mild steel in chemical industries due to its low cost and easy availability like fabrication of various reaction vessels, tanks, pipes etc. Mild steel is prone to atmospheric corrosion as well as in acid media due to its high reactivity with oxygen and with acids.

It suffers from severe corrosion in acidic media thus it becomes essential to protect it from corrosion in working conditions. Many organic compounds in addition to natural products have been used to prevent the corrosion of mild steel in acidic media[1-2].

These compounds adsorb on metal surface and form a barrier to oxygen and moisture by complexing with metal ions or by removing corrodants from the environment, thus inhibit the corrosion. Some of the inhibitors facilitate formation of passivating film on the metal surface. Generally the organic compounds containing hetero atoms like O, N, S are found to work as effective corrosion inhibitor[4-5]

The efficiency of these compounds depends on the electron density around the heteroatom. Heteroatoms such as O, N and S are capable of forming coordinate covalent bond with metal owing to their free electron pairs. Inhibition efficiency also depends upon the number of adsorption active centers in the molecule, their charge density, and molecular size, mode of adsorption and formation of metallic complexes[5].

Corrosion of mild steel and its alloys in different acid media have been studied[6]. Some workers have studied coorrosion inhibition efficiency of Mannich bases for mild steel in acid media. Present investigation deals with the synthesis of Mannich bases and study them as corrosion inhibitor.

The synthetic utility of Mannich reaction is evident from its application in the synthesis of many natural products and biologically important compounds.



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The adsorption of the inhibitors on the metal surface decreases the corrosion rate. The most efficient inhibitors are compounds containing bonds. The adsorption of these compounds is influenced by the electronic structures of inhibiting molecules, steric factor, aromaticity, electron density at the donor site, molecular area and molecular weight of the inhibitor. Compounds having functional groups such as –CHO, -CO, -N=N and R-OH also act as good anticorrosive inhibitor.

## 2. Experimental

### 2.1 Synthesis of Mannich Base

Mannich reaction is a three component condensation reaction in which an active H atom (substrate) is allowed to react with an aldehyde or ketone and primary or secondary amine, concomitant release of water to produce a new base known as a Mannich base.

### 2.2 Weight Loss Tests

Weight loss measurements were performed at different concentration of inhibitor for 1 h by placing the mild steel coupons into the acid solution. At the end of the testing period, the specimens were cleaned and finally its weight loss was recorded. The corrosion rate (*Vcorr*), inhibition efficiency (IE %) and surface coverage ($\theta$) were determined by the following equations

$$\text{Surface Coverage } (\theta) = W_0 - W / W_0$$
$$\text{Inhibition Efficiency (IE \%)} = (W_0 - W / W_0) \text{ X } 100$$

where $W_0$ and W are the weight losses of mild steel without and with the inhibitor respectively. It was assumed that the surface was saturated with adsorbed inhibitor molecules, that is $\theta = 1$.

### 2.3. Scanning Electron Microscopy (SEM)

The surface morphology of the mild steel specimen immersed in acid in the absence and presence of mannich base was recorded by using a Scanning electron microscopy

### 2.4. Effect of Temperature

In order to study the effect of temperature on the inhibition characteristic of Mannich bases, weight loss measurements were performed at different temperatures from in the absence and presence of different concentrations of inhibitors for 2-3 h immersion time.

## 3. Results and Discussion

### 3.1. Effect of Temperature

It is clear that the inhibition efficiency decreased at the studied temperature range which indicated desorption of inhibitor molecules to some extent with increasing temperature.

### 3.2. The Mechanism of Corrosion Inhibition

The mechanism of corrosion inhibition can be explain on the basis of adsorption mechanism. The investigated inhibitors can adsorbs in acid on mild steel surface in four ways namely,

I. Electrostatic interaction between the charged molecules and the charged metal,
II. Interaction of unshared electron pairs in the molecule with the metal,
III. Intraction of -electrons with the metal and
IV. A combination of types (i–iii)

Concerning inhibitors, the inhibition efficiency depends on several factors; such as the number of adsorption sites and their charge density, molecular size, heat of hydrogenation, mode of interaction with the metal surface and the formation metallic complexes. The order of efficiency of both the inhibitors is as follows:

INH-2 > INH-1

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The efficiency in INH-2 over INH-1 is due to the presence of three additional –OH group in INH higher inhibition -2. It is a well-known fact that the inhibitors not only offer electrons to metal atoms but also have unoccupied higher energy orbital to accept electrons from d-orbital of metal atom for strengthening of bonding interaction. In acid solution mild steel surface bears positive charge; it is difficult for the protonated molecules to approach the positively charged mild steel surface ($H_3O^+$/metal interface) due to the electrostatic repulsion.

Since chloride ions have a smaller degree of hydration, they could bring excess negative charges in the vicinity of the interface and favor more adsorption of the positively charged inhibitor molecules, the protonated inhibitors adsorb through electrostatic interactions between the positively charged molecules and the negatively charged $Cl^-$ ions. Thus, there is a synergism between the adsorbed $Cl^-$ ions and protonated inhibitors. Hence, we can assume that the inhibition of mild steel corrosion in 1 M HCl is due to the adsorption of Mannich bases on the mild steel surface.

## 4. Conclusion

Mannich bases are good corrosion inhibitors for mild steel corrosion in acid solution. The inhibition efficiency of both inhibitors increases with inhibitor concentration. The adsorption of Mannich bases on mild steel surface obeys the Langmuir adsorption isotherm.

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