Corrosion inhibition activity of Pyrazole derivatives on metals and alloys in acidic environment: A review

Abhinay Thakur, Ashish Kumar *

School of Chemical Engineering & Physical Sciences
Lovely Professional University, Punjab.

Abstract

The continuous exploration for more effective and environmentally friendly corrosion inhibitors appears to be a main focus in corrosion control. Because of the wide applications in countering the wastage of metals and their alloys, use of organic compounds to prevent corrosion have taken on considerable prominence. Due to extreme coating formation by absorption on the metal surface, such compound has shown considerable potency for reducing aqueous corrosion. The research attempts focused on various features of pyrazoles including synthesis, their activity in metals and alloys corrosion inhibition and exploring their potential. Throughout this concise review, the goal is to reveal the tendency of pyrazole derivatives as corrosion inhibitor.

Keywords: pyrazole derivatives, synthesis, acid, inhibitor, corrosion inhibition

1. Introduction

Corrosion is a thermodynamic viable mechanism that is an afflictive issue with all metal and alloys. Corrosion risk leads to high costs for the repair and safety of used materials [1]. Introduction of corrosion control techniques is a hurdle for researchers working in this field. Use of inhibitors is a desirable and perhaps most effective approach for protecting metals in liaison with corrosion media amongst various techniques evolved for corrosion control. Through restricting the metal dissolution and ingestion, inhibitors minimize corrosion of metallic equipment. To reduce corrosion to a certain level, numerous organic compounds has been used as a corrosion inhibitor whereby pyrazole and its derivatives were identified as an outstanding corrosion inhibitor for various metals and alloys[2]. Pyrazole is an organic heterocyclic compound that has a five member ring framework with 2 adjacent nitrogen atoms and 3 carbon atoms. That focus has been given over most of the decades to pyrazole derivatives that are synthesized on the pyrazole as central core. The central core includes a 5-member organic heterocyclic compound containing 2 adjacent nitrogen atoms. Pyrazole compounds have indeed been revealed to be inhibitors toward metal corrosion and its alloys. These inhibitors activity relies on the direct contact of the functional groups with the metallic surface. The existence of nitrogen (which is electronegative in nature) in molecules enhances the adsorption abilities of inhibitor on metallic surface. The adsorption of inhibitors on metallic surface are whether chemisorption or physisorption, depending on the structure of the bonds between inhibitor molecules as well as metal surface[3]. Molecules containing all nitrogen, oxygen and sulfur become especially important because they have an exemplary inhibition tendency compared to compounds containing only one of them. In this report, numerous pyrazole derivatives have been examined in acidic / basic solution for their inhibition towards metals and alloys corrosion.
2. Synthesis

Pyrazoles have been synthesized by the hydrazine and consequent dehydrogenation reaction of α, β-
unsaturated aldehydes.

Substituted pyrazoles are formed by hydrazine condensation of 1,3-diketones [5]. eg. acetylacetone and
hydrazine together forms 3,5-dimethylpyrazole:

\[
\text{CH}_3\text{(CO)CH}_2\text{C(O)CH}_3 + \text{N}_2 \rightarrow \text{(CH}_3\text{)}_2\text{C}_2\text{HN}_2\text{H} + 2\text{H}_2\text{O}
\]

3. Pyrazole derivatives as corrosion inhibitors

A systematic review reveals that pyrazole derivatives as corrosion inhibitors, generally appear to suppress
dissolution of metals and alloys in alkaline and acid media [4]. Some of the investigated pyrazole
derivatives as corrosion inhibitors have been shown down below Table 1.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Inhibitor</th>
<th>Metal/ Alloy</th>
<th>Medium</th>
<th>Ref(s)</th>
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</thead>
</table>
| 1.    | 1-\{[benzyl-(2-cyano-ethyl)-amino]-methyl\}-5-
methyl-1H-pyrazole-3-carboxylic acid methyl
ester | Mild steel | 1 M HCl | [5]    |
| 2.    | 3,5-diphenyl-4,5-dihydro-1H-pyrazole-1-
carbothioamide | Mild steel | 1 M HCl | [6]    |
| 3.    | 2H-pyrazole-triazole | Mild steel | 1 M HCl | [7]    |
| 4.    | 5-Chloro-1-Phenyl-3-methyl Pyrazolo-4-
methinethiosemicarbazone | C- steel | 1 M HCl | [1]    |
| 5.    | 5-bromo-N-\{(3,5-
dimethyl-1H-pyrazol-1-y1)
methyl\} pyridin-2-amine | Stainless steel | 1 M H_2SO_4 | [8] |
| 6.    | N2-bis ((3,5-dimethyl-1H-
pyrazol-1-y1) methyl)
ethane-1,2-diamine | Mild steel | 1 M HCl | [9]    |
| 7.    | 3-Amino-5,5-diphenyl-4-
oxo-4,5-dihydropyrazole | Carbon steel | 0.5 M HCl | [10]   |
| 8.    | 3(5)-amino, 5(3)-phenyl
pyrazole | 67/33 brass | 0.1 M HCl | [11]   |
| 9.    | 3(5) amino, (4’-
chlorophenyl] pyrazole | Zinc | 0.06 M HCl | [12]   |
| 10.   | 5-(4-Chlorobenzoyloxy)-
1-phenyl-1H-pyra-
dole-3-carboxylate | Mild steel | 15% HCl | [13]   |
| 11.   | 4,4’-
(phenylmethylene)bis(3-
pyrazolyl) | Mild steel | 1 M HCl | [14]   |
4. Mechanism of inhibition

Corrosion inhibition via pyrazole derivatives might include either chemisorption or physisorption of inhibitors to the metallic surface[16]. The mechanism of inhibition can be understood by the adsorption of an pyrazole derivative i.e. 5-(4-methoxyphenyl)-3-(4-methylphenyl)4,5-dihydro-1H-pyrazol-1-yl-(pyridin-4yl)methanone. Mahendra Yadav et al.[13] examine the stated pyrazole derivative corrosion inhibition on mild surface and described the inhibition mechanism where they deliberated that the examined inhibitor get adsorbed on metallic surface and forms a defensive layer between metal and acidic solution interface [17]. The molecules of inhibitor get adsorbed on the metallic surface by the donor–acceptor interactions between π-electrons of the heterocyclic ring and vacant d orbitals of metallic surface.

Figure 1. Inhibitor molecule adsorption on Fe surface.

5. Conclusion

A recognized activity of the pyrazole derivatives as inhibitors to prevent corrosion of metals and alloys used in harsh environments has been investigated. These analyses revealed that various pyrazole derivatives showed significant inhibition efficiency, particularly those who have O, S and N heteroatoms. Pyrazole compounds satisfy the essential criteria to be deemed environmentally friendly due to their low toxicity and appropriate inhibition capacity, and also have proven to be effective inhibitors of metal and alloy corrosion. These derivatives behave as mixed sort inhibitors and the inhibition efficiency has been observed to increase with increased concentration of the inhibitor. Due to the existence of free pairs of electrons, heteroatoms (O, N and S) and aromatic ring, these derivatives became extraordinary corrosion inhibitors till date.
References


