Corrosion Inhibition Activities of Chemical Compound for Mild Steel in Hydrochloric Acid

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Abstract:

Corrosive solution (Hydrochloric acid) has been over and over utilized in manufacturing processes, covering cleaning pickling, acid descaling by acids and oil fully acidize. Inhibition effect of the inhibitor named "2-(((1H-benzo[d]imidazol-2-yl) imino)methyl)phenol" [BIMP] on mild steel in 1 M hydrochloric acid has been scanned employing a technique named weight loss. The results of the study reveal that the inhibition efficiency of BIMP depends on its concentration and attains approximately 81.4% at 0.5 g/L. It is found that the BIMP shows significant action as an inhibitor for mild steel corrosion in corrosive media. BIMP has efficiency raised regarding to temperature decreasing and raising BIMP concentrations.

Keywords: Corrosion, Inhibition, BIMP, Recrystallized, Chloroform, 2-hydroxybenzaldehyde, 1H-benzo[d]imidazol-2-amine.

الخلاصه

كثيرا ما يستخدم حامض الهيدروكلوريك في العمليات الصناعية التي تنطوي على عمليات التنظيف بالحامض وإزالة الأحماض الحامضية، وحموض أبار النفط. تم في الدراسة الحالية التحقق من تأثير تثبيط مشتق الفينول (benzo[d]imidazol-2-yl)imino)methyl)phenol 1H-)))-2) في(1) مولاري من حامض الهيدروكلوريك على الفولاذ الطري باستخدام تقنية فقدان الوزن. تم أجراء الفحص السطحي من خلال مسح المجهر الإلكتروني. أظهرت نتائج الدراسة أن كفاءة تثبيط مشتق الفينول تعتمد على تركيزها وتبلغ حوالي (81.4%) عند (0.5 جم/ لتر) . وقد وجد أن مشتق الفينول يملك أداء جيد كمثبط للتأكل على الفولاذ الطري في المحاليل الحامضية كما ولوحظ زيادة في كفاءة التثبيط مع زيادة تركيز المثبط وانخفاض درجة الحرارة.

الكلمات المفتاحية: تأكل، تثبيط، مركب كيميائي مشتق الفينول، بلورته، الكلوروفورم، مركب ثنائي الهيدروكسيبنزادايد، مركب الهيدروبينزواميدازول ثنائي امين.

1. Introduction

Phenomena that were named corrosion can be defined as a natural approach that results in significant squandering of manufacturing exploitation. Corrosion inhibitor was popular for protects the alloys and steel structures in manufacturing. Such phenomenon could find in various kinds of alloy surfaces bring about main economic damages in the manufacturing sector (Ahamad *et.al.*, 2010). Corrosion inhibiting coatings were mainly utilized to inhibit the rate of corrosion and increase longevity of the MS (mild steel). Many organic adsorption inhibitors presently employee in the corrosion domain are expensive. (Ramarajan *et.al.*, 2017). Chemicals that employed as inhibitors for corrosion process were extremely toxic even with slight, concentrations, steering to ecological agencies demand danger. Controlling corrosion involve various appearance such as ecological, economic and technical generating in main advances of sciences. An important notice was centralized on the handling of the inhibitors and the chemicals sediment aiming health and ecological preventive (Pandey *et.al.*,2017). Many structures in addition to mechanical apparatus, like elbows if pipelines nets and fan of the ship, could suffer from erosion/corrosion issues. It is generally accepted that the 1st step in the adsorption of natural or organic inhibitor molecules on the surface of alloys usually involves replacement of water molecules adsorbed at the metal surface (Bardal, 2003). In the prior, mobile liquid particle issued the damages, while collapsing steam bubbles stimulate damage to the surface in the latter (Chen,2006). Fontana determines erosion as the increasing at average of decay or attacks on a metal surface due to proportional movement amidst a corrosive solution and the surface of the metal (Elvis , 2008). Because of the etching process of acid solution, inhibitors are predominating utilized to diminish the average of decay of metal surface. Most of the inhibitors were organic molecules having heteroatoms such as nitrogen, oxygen, and sulfur atoms and also heterocyclic compounds in addition to delocalized pi-electrons (Fontana,1986). Polar molecules are generally observed as a center of reaction for establishment of the process of adsorption (Arellanes-Lozada, 2008). It is usually accepted that inhibitors (organic molecules) inhibits the process of corrosion through adsorption at the metal solution interface (Quartarone *et.al.*,2008), action the adsorption layer to work as a block and separate the surface of the metal from the corrosion (Roberge, 2000). Weight loss method was utilized to determine the corrosion proportion of the surface of mild steel and the inhibition efficiencies of the BIMP as shown in Figure 1.

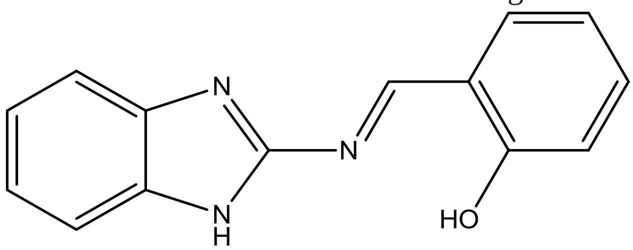


Figure1. The chemical structure of BIMP.

2. Experimental part

The utilization materials in this study supplied from Fluke and Sigma-Aldric without further purifications. The FTIR-infrared spectroscopy (Fourier transform) have been utilized to get an absorption spectrum of infrared for the complexes and were recorded in the range of (4000–200) cm−1 based on cesium iodide disks using a FTIR-8300 Shimadzu Spectrophotometer. Nuclear magnetic resonance spectroscopy (Proton-NMR), determines the physical and chemical characteristics of the molecules in which they are contained and could provide detailed information about the structure of the synthesized complexes. All were recorded on 300 MHz Bruker-DPX

3. Synthesis of the BIMP.

A mixture of 2-hydroxybenzaldehyde and 1H-benzo[d]imidazol-2-amine in a molar ratio of (1:1) have been well-stirred with refluxing in 50 mL of alcohol (methanol) and glacial acetic acid as drops for 6hrs. Reaction solution have been cooled, and filtered to extracte the precipitate that was washed 3-times with chloroform. The yield was 77%, and the melting point 141-143 ^{o}C. BIMP was characterized by FTIR and NMR spectroscopies and also by CHN analysis technique. Purity of the BIMP was checked by TLC. The molecular structure of 2-(((1H-benzo[d]imidazol-2-yl) imino) methyl) phenol is given in Figure 1. IR: 3237 (N-H str.), 3120 (O-H str.), 1689 (C=O str.) 1631 (C=N str.), 1587 (C=N str.) 1219 s and 1076 1317 and 1159 (asy and sy C-O). 1H NMR (δ ppm, DMSO-d6), s, 5,31 (OH), s, 5.01 (NH), m, 6.914-7.34 (Aromatic). Elemental Analysis: C, 70.87 (69.44); H, 4.67 (5.02); N, 17.71 (18.02).

4. Weight loss measurements

Mild steel samples with the dimensions of 0.5 cm^3 have been employed for the technique of weight loss. The sheets were abraded utilizing emery paper, then, distilled water used for washing them firstly then acetone secondly dried at room temperature. The weighing all the sheets by an analytical balance before immersion. Then, the sheets immersed in 1 M hydrochloric acid solutions (100 mL) without and with the studied inhibitor concentrations. After a period time of immersion, the samples were washed, dried and weighed. The methodology was done in triplicate.

The rate value of the weight loss was considered. The inhibition efficiencies were calculated using Equation 1.

$$IE\% = \frac{w_2 - w_1}{w_2} \times 100 \qquad (1)$$

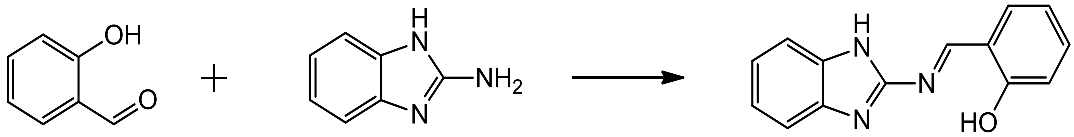
Where W_2 and W_1 are the corrosion weights of mild steel without and with inhibitors respectively.

5. Statistical analysis

The tested inhibitor was investigated. Each concentration has been analyzed individually in triplicate and data are reported as mean (n = 3) ± SD. Data were studied utilizing analysis of variance (ANOVA). A probability value of $p \leq 0.05$ have been investigated to denote a statistical significance versions.

6. Results and Discussion

BIMP, have been found by the condensation reaction for the chemical compounds namely 2-hydroxybenzaldehyde with 1H-benzo[d]imidazol-2-amine. Steps for the reaction formation 2-(((1H-benzo[d]imidazol-2-yl) imino) methyl) phenol, is displayed in Figure 2.



2-hydroxybenzaldehyde 1H-benzo[d]imidazol-2-amine 2-(((1H-benzo[d]imidazol-2-yl)imino)methyl)phenol

Figure 2. Chemical reaction of 2-hydroxybenzaldehyde with 1H-benzo[d]imidazol-2-amine for synthesis of target inhibitor.

6.1. The effect of concentrations of corrosion inhibitor

Figure 3, displays the variations, in the abilities of efficiencies to inhibit the corrosion on the mild steel surface versus time in hours in corrosive solution that have hydrochloric acid with one molar concentration (1M HCl).

The presence of various, concentrations of the target inhibitor namely BIMP led to various inhibition efficiencies and it can be said that adding the highest concentration of BIMP to the corrosive solution give the highest inhibition efficiency. It was also observed that the addition of the low concentration of BIMP led to lowering in inhibition efficiency compared to that of the 0.5 g/L as concentration of BIMP. From above, it can be concludid that BIMP is an excellent corrosion inhibitor for mild steel in the hydrochloric acid solutions.

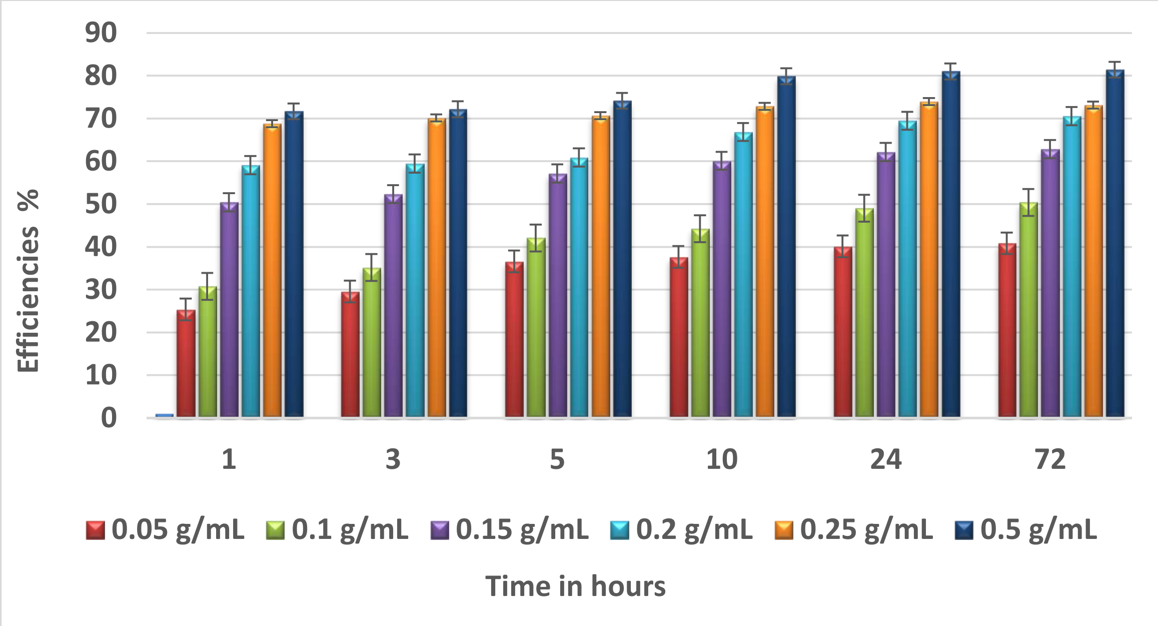


Figure 3. The version concentrations of BIMP as an inhibitor for the mild steel comparing with the times.

6.2.Changes of Temperatures

Inhibition efficiencies of different concentrations of BIMP starting from 0.05 g/L, and ending at 0.5 g/L, for mild steel in a solution of hydrochloric acid at different temperatures (303, 313, 323 and 333 K) refer to that inhibition efficiencies decrease in the height highest temperature degree and the best inhibition efficiencies that at the room temperatures. Figure 4 refers to the impact of changing temperatures degrees on the efficiencies of inhibition for of BIMP at range of concentrations.

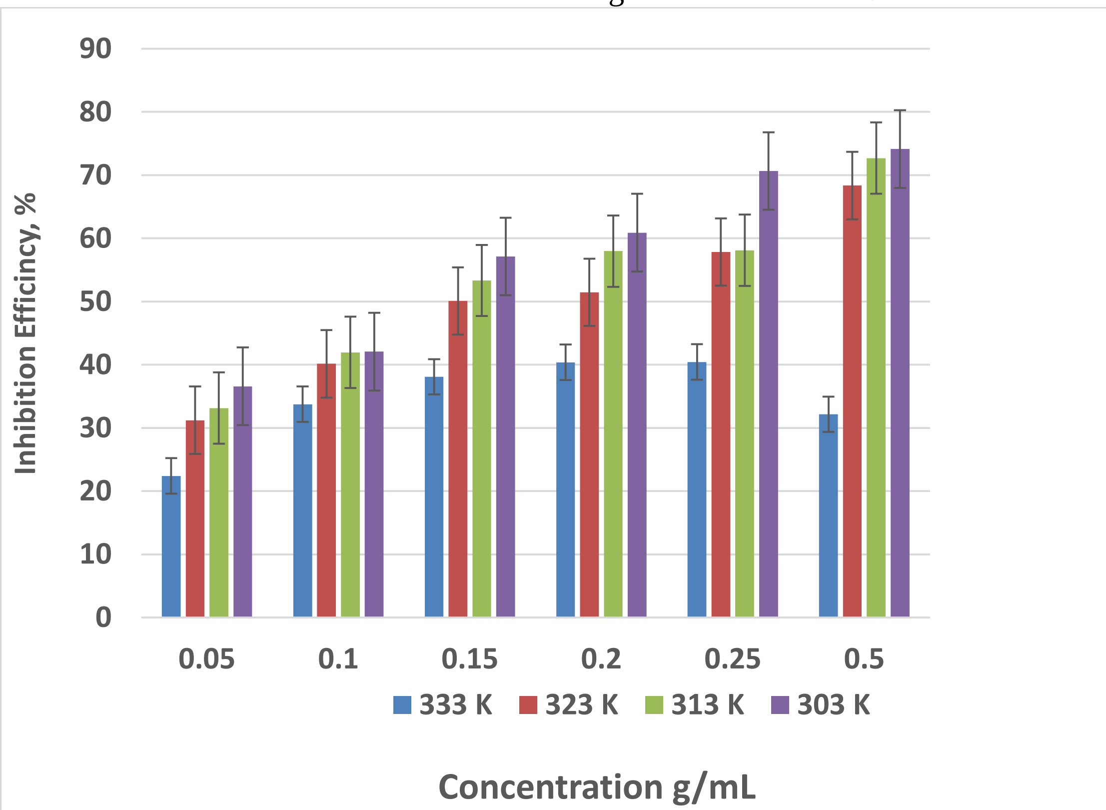


Figure 4. The effect of changing of temperature degrees on efficiencies of 2-(((1H-benzo[d]imidazol-2-yl) imino) methyl) phenol.

6.3. Scavenging activity of mild steel.

Significant characteristics of BIMP as inhibitor for the atoms on the surface of the mild steel. The inhibitor molecules donation the pairs of electrons to the un-occupied orbital of iron at the orbital.In other word the metal will scavenge pairs of electrons of BIMP molecules to produce complex to the surface of mild steel and this surface will protect the surface from corrosion.

6.4. Suggested inhibition mechanism

The mechanism for the action of BIMP as inhibitor for mild steel, have been as demonstrated in Figure 5. The formation of metal complex between the BIMP and iron atoms at the surface of mild steel is the most accepted mechanism and this mechanism would be under the effect of structure of the inhibitor. The structural effect of BIMP depends on the nitrogen and oxygen atoms in addition to the aromatic rings that have ability to release electron pairs, while the iron atoms on the surface have the ability to capture these pairs of electrons and form the metal complex due to the d-orbitals in the iron atoms, resulting in stability of the complexes.

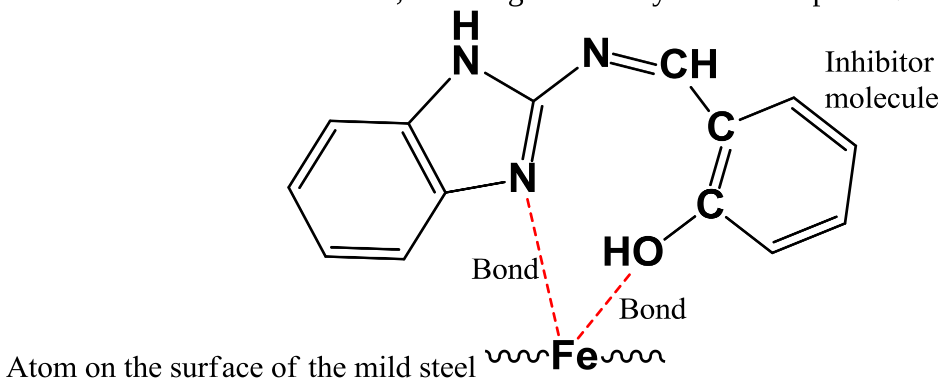


Figure 5. Suggested mechanism for inhibition action.

7. Conclusion

Mild steel corrosion inhibitor was synthesized, and it structure was fully characterized by spectroscopic techniques. The capability to inhibit corrosion of mild steel in corrosive solution at various temperature degrees was subsequently investigated. The inhibitor, 2-(((1H-benzo[d]imidazol-2-yl) imino)methyl)phenol" [BIMP] exhibited good corrosion inhibition activity, and highest inhibition performance of 81was demonstrated for BIMP, at an inhibitor concentration of 5 g/mL. The inhibition performance increased with raising of BIMP concentration, whereas inhibition performance diminished with raising temperature.

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