Anticorrosion and antibacterial effects of new Schiff base derived from hydrazine

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Abstract. In general, the diminish of corrosion is controlled by different techniques. Typically, the applied corrosion inhibitor was proved to be a simple and inexpensive technique for corrosion prevention and protection in a corrosive environment. Herein we synthesized a new corrosion inhibitor namely “Benzyl 2-(1-(5-methyl-1-(p-tolyl)-1H-1,2,3-triazole-4-yl)-ethylidene) hydrazine-1-carbodithioate” (BTC). The chemical structure of the tested inhibitor has been elucidating by FT-IR and NMR spectroscopically methods and the number of carbons hydrogen and nitrogen atoms for chemical formula was detected through using CHN analysis. BTC was investigated as a novel inhibitor for mild steel (MS) in an HCl environment, and the inhibition efficiency has been tested gravimetric technique. The results showed that the corrosion rate (CR) and inhibition efficiency (IE%) are in an inverse relationship with each other, as the IE increases with increasing the inhibitor concentration while the CR decreases with increasing concentration. The inhibition efficiency was up to 93.4% at 303.0K in presence of BTC (0.5 mM). The IE decreases with increasing temperature especially at 333 K. The adsorption of BTC on the MS surface was obeyed the adsorption of Langmuir isotherm. In a parallel study, the BTC was examined as an antibacterial compound for Escherichia coli and Staphylococcus aureus. The results showed that the new substance has the significant potential to inhibit the growth of bacterial.

Keywords: corrosion inhibitor, weight loss, antibacterial, mild steel

1. Introduction
Organic materials that act as corrosion inhibitors are very important for protecting metals in acid and basic solutions from corrosion processes [1]. The organic compounds used against corrosion are often molecules that contain one or more heterogeneous atoms (sulfur, phosphorus, oxygen, and nitrogen). The inhibition technique of these organic molecules in corrosive environments is generally attributed to the ability of these organic molecules to be adsorbed in corrosive media on the mineral surface [2].
In addition, the recent tendency in alloys protection towards eco-friendly or green or non-toxic inhibitors [3]. Researchers in the field of corrosion and industry are often searching for organic compounds with possible inhibitory properties as well as being economical, non-toxic, and dissolve in aqueous solutions to control or reduce the corrosion of metals which use in industrial processes. One of the most important of these organic compounds with great ability to inhibit the corrosion of the metals in corrosive environments and economically feasible is Schiff bases [4-6]. Moreover, it is known that the temperature affects the behavior of minerals in acidic and alkaline solutions, which mostly affects the adsorption of inhibitor molecules to the mineral surface [7]. Furthermore, in a corrosive environment, the rate of corrosion of metals increases with increase temperature [8]. Consequently, the behavior of corrosion inhibitors in such solutions is good understanding and it significant in assessing the corresponding risk parameters [9].

Indeed, the selection of suitable inhibitor depends on criteria such as corrosive environment type, temperature, and fluid flow velocity [10] Several investigations have examined the corrosion inhibition of mild steel in corrosive environments and the effect of temperature on the presence of non-toxic organic inhibitors [11]. For example, Mohamad et al. [12] investigated the synergistic of a coumarin derivative with potassium iodide on the corrosion inhibition of aluminum alloy. Furthermore, Salman, et al. [13] tested the effect of high temperature and inhibitive corrosive characteristics of thiadiazol on mild steel in a hydrochloric acid environment. Moreover, in different investigations, the effect of temperature on the corrosion inhibition of steel was performed by a new corrosion compounds in a hydrochloric acid solution by Habeeb et al. [14].

Al-Amiery et al. [15] were evaluated the inhibitory potential of chlorocurcumin on corrosion of steel in a hydrochloric acid environment at various temperatures. Continuing with our research on corrosion, we present our new research [16-25] work focuses on the assessment of the inhibitive performance of newly synthesized corrosion inhibitor namely benzyl 2-(1-(5-methyl-1-(p-tolyl)-1H-1,2,3-triazole-4-yl)-ethylidene) hydrazine-1-carbodithioate" (BTC) on mild steel corrosion under different temperatures and inhibitor concentrations. The presence of the BTC was examined as an antibacterial compound for Escherichia coli and Staphylococcus aureus.

2. Materials and Methods

2.1 Synthesis and Characterization of BTC
An ethanolic solution of 1-(5-methyl-1-(p-tolyl)-1H-1,2,3-triazole-4-yl)-ethylidene hydrazinecarbodithioate (10.0 mmol) and benzyl hydrazinecarbodithioate (10.0 mmol) was refluxed for 5.0 h. The resulting mixture was then filtered and recrystallized from the ethanol.

The yield product was 60% and the melting point is 232.5 °C. Fourier Transformer Infrared (FT-IR) analysis showed: peak 3397.3 cm\(^{-1}\) (amino group), 3050.0 cm\(^{-1}\) (C-H aromatic), 1608.4 cm\(^{-1}\) (C=N), 1545.2 cm\(^{-1}\) (C=C). Nuclear Magnetic Resonance (NMR) analysis showed: δ = 2.38 ppm (3H, singlet, CH\(_3\) aromatic), 2.94 ppm (3H, singlet, allylic CH\(_3\)), 3.17 ppm (3H, singlet, triazol-CH\(_3\)), 3.37 ppm (2H, singlet, benzyl CH\(_2\)), 7.33–7.42 ppm (9H, aromatic) and 10.98 ppm (1H, singlet, amine). Carbon (C), Hydrogen (H) and Nitrogen (N) analysis for C\(_{20}\)H\(_{21}\)N\(_5\)S\(_2\): found/calculated: C, 61.11 (60.73); H, 5.91 (5.35); N, 18.09 (17.71).

a. Solutions
The corrosive environment of 1N hydrochloric acid required for studies of corrosion inhibition examinations were prepared through adding HCl 37% analytical grade to deionized water. The
concentrations of inhibitory solutions were prepared by dissolving the corrosion inhibitor in the corrosive solutions with concentrations of 0.1 to 0.5 mM [26].

b. Weight Loss Measurements

Coupons of mild steel with dimensions 4.5 x 2.0 x 0.5 cm³ were utilized for gravimetrical techniques. Prior to the experiment, the tested coupons were abraded by sheets of silicon carbide with different degrees, washed with double distilled water and acetone then dried. The weight of each tested coupon was calculated. The mild steel coupons were immersed and adjusted utilizing fishing lines in a corrosive environment at various temperature rang (303-333) and with various BTC concentrations. The mild steel coupons weight loss was recorded after 1, 5, 10, and 24 h. as exposure time [27-29]. The corrosion rate (CR) [30,31] and inhibition efficiency (η) [32,33] have been calculated by applying equations (1 and 2).

\[
CR = \frac{KW}{DST} \quad (1)
\]

where \(D\) is the coupon density (g/cm³), \(S\) is the area of the coupon (cm²), \(T\) is the exposure time, \(K\) is the constant, and \(W\) average coupon weight loss (g).

\[
\eta\% = \frac{C_{Ro} - C_{Rinh}}{C_{Ro}} \quad (2)
\]

where \(C_{Ro}\) is the corrosion rate in the absence of BTC and \(C_{Rinh}\) is the corrosion rate in the presence of BTC.

c. Antibacterial Activities

The in vitro antibacterial activities of the BTC as were determined versus Staphylococcus aureus and Escherichia coli as Gram-positive and negative bacteria, by the disc diffusion technique [34,35] using nutrient agar medium. The sub-cultured tested bacteria in agar medium and were incubated for 24 hours at 37 °C. The 5 mm diameter of discs immersed in the examined medium with the appropriate convenient amount of the BTC dissolved in DMSO (sterile) at concentrations of 0.1-0.5 mM and were placed in Petri dishes on a suitable medium previously seeded with bacteria and stored in an incubator for the above-mentioned exposure time. The zone of inhibition around each disc was evaluated and recorded in the form of inhibitive zone in mm. To exhibit any effectiveness of the solvent on the antibacterial examination, separate investigations were performed utilizing dimethylsulfoxide as control and it demonstrated no activities versus tested organism.

3. Results and Discussion

a. Chemistry

The synthesis of BTC was carried out by refluxing benzyl hydrazinecarbodithioate with 1-(5-methyl-1-(p-tolyl)-1H-1,2,3-triazol-4-yl)ethanone, in ethanol. The end of the reaction involves the removal of the water molecule and the production of BTC in 60% yield (Figure 1).

![Figure 1. The reaction synthesis of BTC](image-url)
b. **Weight Loss Tests**

The weight loss of mild steel coupons was evaluated after exposure to various times (1, 5, 10, and 24 hours) at various temperatures (303, 313, 323, and 333 K).

c. **Weight Loss-Concentration effect**

The examined BTC reduce the mild steel corrosion at low and high concentration in corrosive environment at 303 K. A plot of the corrosion rate versus inhibitor concentration shows that the corrosion rate (mmy⁻¹) gradually reduced with increase the concentration of BTC as demonstrated in Figure 2. The inhibitive performance was increased with increasing the concentration of the inhibitor. The highest inhibition efficiency of 94% was obtained at the BTC concentration of 0.5 mM as in Figure 3. It is observed that BTC reduce and control the mild steel corrosion at all studied concentrations utilized in this investigation. This can be attributed to the adsorption of BTC molecules on the surface of mild steel. This adsorption reduces the mild steel dissolution through the block the corrosion sites and increasing the inhibitive performance.

![Figure 2. The corrosion rate at various concentrations of TCB for various immersion time.](image-url)
\textbf{Weight Loss-Temperature effect}

The values of inhibition efficiency at various temperatures (303, 313, 323, and 333K) is demonstrated in Figure 4. The results showed that the presence of BTC molecules reduces the corrosion rate of mild steel coupons in the corrosive environment. The inhibition efficiency exhibited an increase when increasing the BTC concentration as shown in Figure 4. At higher studied Temperatures, the inhibition efficiency was noted to decrease when increasing Temperatures even with the increasing BTC concentration. This may be due to the desorption of the BTC molecules on the mild steel surface.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Inhibition efficiency at various concentrations of TCB for various immersion times}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Inhibition efficiency at various concentrations of TCB for various Temperatures}
\end{figure}
e. The antimicrobial activities

The antimicrobial assays data exhibited that the BTC show antibacterial characteristics, and we note that the BTC exhibited more inhibitory effects than the parent benzyl hydrazinecarbodithioate or 1-(5-methyl-1-(p-tolyl)-1H-1,2,3-triazol-4-yl)ethanone. The increased inhibition efficiency of the BTC can be demonstrated in the existence of the \( \text{C}=\text{N} \) bond [36]. It is known that the imine group has the tendency to make the BTC act as a powerful and potent bactericidal factor, thus killing more of the bacteria than the two compounds which form the BTC. It has been shown that, in a BTC molecule, the positive partial charge is partially shared with the double bonds present in the BTC molecule, and there may be \( \pi \)-electron delocalization over the whole BTC molecule space [37,38]. This would increase the lipophilic parameter of the BTC molecule and favors its permeation through the lipid layer of the bacterial membrane. The lipophilic factor which increasingly seems to be responsible for enhanced potent antibacterial activities. It might be proposed that BTC molecule has the ability to de-activate different cellular enzymes, that play a vital role in different metabolic pathways of the tested bacteria. Furthermore, it may be suggested that the final vigor of the toxicant is the denaturation of one or more proteins of the cell, which as a result, impairs normal cellular processes. There are other parameters that also raise the action, namely "conductivity, solubility, and bond length".

As findings from the investigation of antimicrobial of the BTC molecules (Figure 5), the following conclusions may be stated. In general, the findings of synthesized BTC molecules showed inhibition efficiency against E. coli bacteria was more than the inhibitive on Staphylococcus aureus.

**Conclusions**

In the present investigation, BTC has been successfully synthesized and fully characterized by utilizing different spectroscopic techniques and elemental microanalysis CHN. The synthesized compound was tested for corrosion inhibition and antibacterial efficiencies. BTC indicated significant corrosion inhibitive properties and important antibacterial efficiencies.

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Conflict of interest

The authors declare that there is no conflict of interest

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