Iranica Journal of Energy & Environment
Journal Homepage: www.ijee.net
IJEE an official peer review journal of Babol Noshirvani University of Technology, ISSN:2079-2115

# Corrosion Studies of Carbon Steel in 3% NaCl Solution in Presence of Expired Ceftin: Investigation of Environmental Friendly Corrosion Inhibitor

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*P A P E R  I N F O*

*Paper history:*
Received 22 November 2018
Accepted in revised form 31 december 2018

*Keywords*:
Ceftin drug
3 % NaCl
Weight loss
Gasometric
Atomic absorption spectroscopy

*A B S T R A C T*

In this investigation, the application of Ceftin drug on prevention of the corrosion of carbon steel in 3 % NaCl solution was examined through weight loss (mass loss), gasometric and atomic absorption spectroscopy techniques. The effectiveness of the Ceftin drug as corrosion inhibitor for carbon steel was proved by weight losses, gasometric and atomic absorption spectroscopy results. An increase in the Ceftin drug concentration decreases the carbon steel weight loss in the 3 % NaCl solution, which is due to the formation of invisible thick layer on the carbon steel in the 3 % NaCl solution. An increase in the contact time decreases the corrosion inhibition property of expired Ceftin drug. Gasometric studies showed that, the amount of hydrogen gas evolved decreases with rise in the concentration of 3 % NaCl solution. The results of atomic absorption spectroscopy well support the weight loss (mass loss) and gasometric results.

***doi**: 10.5829/ijee.2018.09.04.10*

## INTRODUCTION

The carbon steel (CS) is important metal because of their wide range of applications in the several industries. CS used in the petroleum industries, chemical batteries and shipment vessels. During several applications, CS contact with NaCl solution. This cause damage to the CS metal. The corrosion of carbon steel is electrochemical process which causes the disintegration of carbon steel in 3 % NaCl solution [1-3]. The disintegration process weakness the carbon steel structure. Hence, prevention of carbon steel is very much essential. The corrosion of CS greatly effects on the nation economy. Hence, prevention of CS corrosion in the NaCl solution is very much essential. Many methods used to control the CS corrosion in the NaCl solution [4-7]. Among them, the utilization of corrosion inhibitors is commonly employed method for the prevention of dissolution process. Most of the corrosion inhibitors are organic compounds which contains N, S, P and O atoms in their moieties. These elements adsorb on the metal surface in the corrosive solution and prevent the corrosion process by blocking the attack of corrosive ions on the surface of the metal. Many organic compounds are reported as corrosion inhibitors. But, these organic compounds are expensive and toxic in nature [8-10]. Hence, in this research selected expired Ceftin drug. The chemical structure Ceftin drug is shown in Figure 1. The expired Ceftin drug is not suitable for consumers, but it retains its biological activity after it's expiring that. Therefore, in current research selected expired Ceftin drug and studied its corrosion inhibition property on CS in 3 % NaCl solution with the aid of gasometric, weight loss and atomic absorption spectroscopy techniques.

## MATERIAL AND METHOD

The 99 % purity of carbon steel (CS) was employed for gasometrical, weight loss and atomic absorption spectroscopy studies. The 3 % NaCl solution (corrosive medium) was prepared by standard procedure. The expired Ceftin drug was collected and concentration of 0.5 mg, 1.0 mg, 1.5 mg and 2 mg of expired Ceftin drug was prepared for corrosion studies.

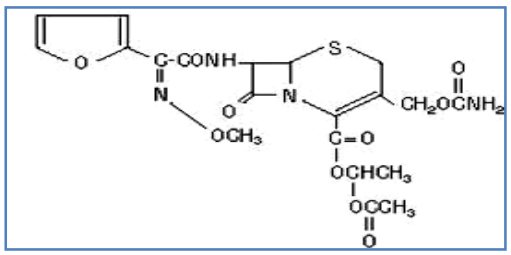


**Figure 1**. The chemical structure of Ceftin drug

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The weight loss, gasometrical and atomic absorption spectroscopy was carried out at room temperature (303 K) with immersion period of 1, 2, 3, 4, and 5 hours .

From the weight loss values of CS (observed from the weight loss technique), the protection efficiency can be calculated from the following equation:

$$Protection\ (corrosion\ inhibition) efficiency\ (\%) = \frac{w_1 - w_2}{w_1} \times 100$$

where, W1= Weight loss of CS in free 3 % NaCl and W2=Weight loss of CS in protected 3 % NaCl .

In the gasometric technique, the protection efficiency of the corrosion inhibitor can be calculated from the amount of gas evolved values as per the following equation:

$$Corrosion\ inhibition\ (protection) efficiency = \frac{v_a - v_p}{v_a}$$

Where, Va= Amount of gas evolved in unprotected system and Vp= Amount of gas evolved in protected system. From the atomic absorption spectroscopy (AAS) results, the protection efficiency can be calculated from the following equation:

$$Protection\ (corrosion\ inhibition) efficiency\ (\%) = \frac{w_1 - w_2}{w_1} \times 100$$

Where, B= the amount of iron content dissolved in 3 % NaCl solution and A= the amount of iron content dissolved in 3 % NaCl in protected system.

## RESULTS AND DISCUSSION

### Weight loss and gasometric results

The obtained results from the weight loss and gasometrical techniques are summarized in Table 1. The protection efficiency of the expired Ceftin drug of four different amounts namely 0.5 mg. 1 mg, 1.5 mg and 2 mg are presented in Table 1. It is observed that, the expired Ceftin drug inhibits the CS corrosion effectively in 3 % NaCl solution. The corrosion inhibition property of expired Ceftin drug is due to the formation protective film on the CS in 3 % NaCl solution. The formed protective layer on the CS in the 3 % NaCl solution blocks the evolution of gas from the CS surface, which decreases the weight loss of CS in 3 % NaCl solution.

Further, the corrosion inhibition property of expired Ceftin drug on the CS surface in 3 % NaCl solution is due to the following interactions:

a) The interaction existing in between the lone pairs electron of S of the expired Ceftin drug and positively charged CS in 3 % NaCl solution .

b) The interaction existing in between the lone pairs electron of N of the expired Ceftin drug and positively charged CS .

c) The interaction existing in between the lone pairs electron of O of the expired Ceftin drug and positively charged CS in corrosive solution .

d)The interaction existing in between the electron rich elements and double bonds of expired Ceftin drug and positively charged CS in corrosive solution.

It is also observed from the gasometric and weight loss studies that, an increase in the contact time from one hour to five hour decreases the protection efficiency of the expired Ceftin drug on the CS surface in 3 % NaCl solution. This nature is due to instability of protective film for longer immersion period. Usually formation of protective film from the molecules of expired Ceftin drug takes some time. The longer immersion period of CS in the 3 % NaCl solution leads to the instability of protective film on the metal surface. The attack of corrosive ions from the 3 % NaCl solution continuously increases at higher immersion period. Hence, free CS metal surface greatly exposed to the 3 % NaCl solution. The exposed CS surface greatly affected by dissolution process. As a result of this, CS corrosion rate (weight loss of CS) enhances with increase in the contact time from one hour to five hour.

### Atomic absorption spectroscopy (aas) technique

For comparison purpose, the atomic absorption spectroscopy (AAS) technique was also carried out at ambient temperature (303 K). The AAS technique was used to measure the concentration of iron content in the CS in the 3 % NaCl solution in protected and unprotected

**TABLE 1**. The results of gasometric and weight loss techniques at 303 K

| Concentration (mg) | Contact time (hours) | Protection efficiency (%) Weight loss technique | Protection efficiency (%) Gasometric technique |
|---|---|---|---|
| 0.5 | 1 | 87.000 | 83.333 |
| 1.0 | | 88.500 | 86.111 |
| 1.5 | | 90.000 | 87.777 |
| 2.0 | | 91.000 | 90.000 |
| 0.5 | 2 | 77.096 | 76.000 |
| 1.0 | | 79.677 | 76.800 |
| 1.5 | | 81.612 | 79.200 |
| 2.0 | | 83.548 | 83.600 |
| 0.5 | 3 | 68.157 | 74.848 |
| 1.0 | | 69.736 | 75.757 |
| 1.5 | | 73.421 | 78.484 |
| 2.0 | | 74.210 | 81.818 |
| 0.5 | 4 | 67.391 | 71.111 |
| 1.0 | | 69.347 | 73.111 |
| 1.5 | | 70.217 | 76.000 |
| 2.0 | | 73.913 | 79.777 |
| 0.5 | 5 | 58.490 | 62.264 |
| 1.0 | | 60.377 | 65.471 |
| 1.5 | | 62.641 | 67.924 |
| 2.0 | | 66.415 | 69.622 |

systems. The protection efficiency of the expired Ceftin drug on the CS surface in 3 % NaCl solution was calculated by knowing the values of amount of iron content in the protected and unprotected system. The results of AAS are shown in Table 2. The AAS results shows that, the iron content in the 3 % NaCl solution is high in the absence of the corrosion inhibitor when compared to the in the presence of the corrosion inhibitor. This observation clear shows the corrosion inhibition property of expired Ceftin drug on the CS in 3 % NaCl solution with concentration dependent mode. The presence of corrosion inhibitor in 3 % NaCl solution decreases the iron content in the corrosive solution by forming the protective layer on the CS surface in 3% NaCl solution. The instability of protective film was observed at higher immersion time, as a result of this, the protection efficiency decreases with increase in the contact time. The results obtained from the gasometric, weight loss and atomic absorption spectroscopy are in good agreement. The protection efficiency obtained from the three techniques (gasometric, weight loss and atomic absorption spectroscopy) is shown in Figure 2.

## CONCLUSIONS

The corrosion inhibition property of expired Ceftin drug on CS in 3 % NaCl solution was scrutinized with the help of gasometric, weight loss and atomic absorption spectroscopy techniques. All the three techniques (weight loss, gasometric and atomic absorption spectroscopy) showed the corrosion inhibition property of expired Ceftin drug on CS in 3 % NaCl solution. Further, the studied techniques showed that, the corrosion inhibition property of expired Ceftin drug is mainly depends on the concentration of the corrosion inhibitor and contact time. An increase in the concentration of the inhibitor increases the corrosion inhibition property of the expired Ceftin drug on CS surface in 3 % NaCl solution. The decrease in the protection efficiency (increase in the CS corrosion rate) was observed with increase in the contact time from one hour to five hours. The results obtained from the weight loss, gasometric, and atomic absorption spectroscopy is in good agreement.

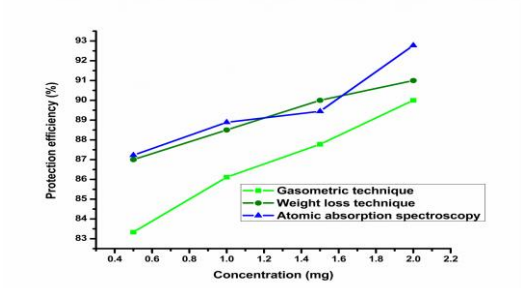


**Figure 2.** The protection efficiency obtained from the three techniques at 303 K with immersion period of one hour.

**TABLE 2.** The atomic absorption results at 303 K

| Concentration (mg) | Contact time (hours) | Protection efficiency (%) Weight loss technique |
|---|---|---|
| 0.5 | 1 | 87.222 |
| 1.0 | | 88.888 |
| 1.5 | | 89.444 |
| 2.0 | | 92.777 |
| 0.5 | 2 | 77.272 |
| 1.0 | | 78.246 |
| 1.5 | | 79.545 |
| 2.0 | | 81.168 |
| 0.5 | 3 | 68.000 |
| 1.0 | | 68.533 |
| 1.5 | | 70.400 |
| 2.0 | | 72.533 |
| 0.5 | 4 | 64.222 |
| 1.0 | | 66.666 |
| 1.5 | | 68.222 |
| 2.0 | | 71.777 |
| 0.5 | 5 | 59.615 |
| 1.0 | | 61.923 |
| 1.5 | | 67.115 |
| 2.0 | | 67.500 |

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**Persian Abstract**

*DOI: 10.5829/ijee.2018.09.04.10*

**چکیده**

در این تحقیق، استفاده از داروهای سفتین در پیشگیری از خوردگی فولاد کربن در محلول ۳ درصد NaCl از طریق کاهش وزن (ضایعات جرمی)، روش های اسپکتروسکوپی جذب اتمی و گاز سنجی مورد بررسی قرار گرفت. اثربخشی داروهای Ceftin به عنوان مهار کننده خوردگی برای فولاد کربن، با کاهش وزن، نتایج طیف سنجی جذب اتمی و گازسوزی اثبات شد. افزایش غلظت داروهای Ceftin باعث کاهش وزن فولاد کربن در محلول ۳٪ NaCl می شود که به علت تشکیل لایه ضخیم نامرئی در فولاد کربن در محلول ۳٪ NaCl است. افزایش زمان تماس باعث کاهش مهار مهار خوردگی مواد مخدر سفتنی می شود. مطالعات گازسنجی نشان داد که مقدار گاز هیدروژن تکامل یافته با افزایش غلظت ۳٪ محلول NaCl کاهش می یابد. نتایج طیف سنجی جذب اتمی به خوبی از کاهش وزن (از دست دادن توده) و نتایج گازومتری پشتیبانی می کند.