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Optimization of the Inhibitor Efficiency of a 1-allyl-5-nitro-2,7a-dihydro-1H-benzo[d]imidazole-2-thiol on Corrosion of Ordinary Steel in 0.5M H_2SO_4

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ABSTRACT: *The present study attempted to investigate the best conditions for the use of 1-allyl-5-nitro-2,7a-dihydro-1H-benzo[d]imidazole-2-thiol as corrosion inhibitor of ordinary steel in 0.5 M H_2SO_4 through the use of surface response methodology. We have drawn up an experimental plan with three factors and two levels per factor in a simple way, without the use of specific software. The response (inhibitor efficiency) was evaluated by the gravimetric method. We have chosen the parameters most used in the corrosion field such as inhibitor concentration, immersion time and temperature. This approach allowed us to find the best conditions for obtaining maximum inhibitor efficiency.*

Keywords: *Steel, Acid solution, Weight loss, Corrosion, Adsorption, 2-Benzimidazolethiol, Experimental Designs.*

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I. INTRODUCTION

The corrosion is not only source of wasting, it can provoke some serious accidents and in certain cases contributed on the pollution of the environment. Acid solutions are widely used for industrial cleaning, oil well acidification and pickling. The idea to use an inhibitor of corrosion is a convenient answer to protect metal and more precisely ordinary steel in acidic media [1]. In general, the organic compounds have demonstrated a great effectiveness in inhibiting the aqueous corrosion of many metals and alloys [2-7]. The inhibiting action of those organic compounds is usually attributed to interactions with metallic surface by adsorption. The adsorption of inhibitors takes place through heteroatoms such as oxygen, phosphorus and sulphur or aromatic rings containing polar groups and π electrons [8]. amines [9-12], mercaptans [13-14], aminothiols [15-17], thio-compounds [18], triazole [19-23], oxadiazoles [24-25], imidazol [26-28], thiazoles [29], phosphonate [30] and carboxylates [31] are used as inhibitors for steel in acid medium.

Inhibitor efficiency% depends on several parameters such as the concentration of the inhibitor, the temperature of the medium, the time of immersion. The influences of these factors were tested by using the methodology of the experimental models [32]. We chose three factors with two levels thus 2^3= 8 possibilities. The model 2k (K factors with 2 levels each one) is most widespread because being the least prohibitory at the financial level while remaining powerful. Among the advantages of the experimental designs are: Reduction amongst tests, Detection of the interactions between factors, modeling of the studied answer and an optimum precision of the results.

II. EXPERIMENTALDETAILS

2.1. Inhibitor:

Fig.1:the molecular formula of 1-allyl-5-nitro-2,7a-dihydro-1H-benzo[d]imidazole-2-thiol.

- Chemical Formula: $C_{10}H_{11}N_3O_2S$
- Molecular Weight: 237, 28

2.2. Specimens

Ordinary steel specimens containing 0.11% C , 0.24 % Si , 0.47% Mn , 0.12% Cr , 0.02% Mo , 0.1% Ni , 0.03% Al , Co< 0.0012% ,Cu 0.14% ,V < 0.003% , W 0.06% and the remainder Fe was used as the substrate.

These steel specimens were mechanically cut into 1cm × 5 cm × 0.06 cm dimensions for weight loss experiment. Prior to all measurements, the specimens were mechanically polished on wet SiC paper (grade 400 – 600 - 1200), rinsed with doubly distilled water, degreased ultrasonically in ethanol for 5 min and dried with hot air.

2.3. Electrolytes

The aggressive solution, 0.5 M H2SO4, was prepared by dilution of analytical grade grade 98% H2SO4 with double distilled water.

2.4. Gravimetric measurement:

The weight loss of steel with and without the addition of different concentration of inhibitor was determined after immersion in sulfuric acidic solution, the percentage inhibition efficiency (η%) was calculated from:

$$\eta\% = \frac{W_0 - W}{W_0}$$

Where W_0 and W are the values of the corrosion weight loss of steel after immersion in solutions without and with inhibitor respectively.

2.5. The strategy of the experimental designs

2.5.1. Establish the objective of the experiment

Our objective is to maximize the inhibitor efficiency.

2.5.2. Identification of the factors

We determined that the three factors principals being able to influence the inhibitor efficiency are: the concentration of the inhibitor, the temperature of the medium and the time of immersion. Having decided to use two levels per factor, brainstorming indicates the values below:

Table.1: The high and low levels of factors

Factor	Low level	High level
Concentration	10^{-6} M	10^{-3} M
Temperature	30 °C	60 °C
Time	24 h	48 h

2.5.3. Determining the design of the experimental plan

So we have three factors with two levels each. The possible combinations are shown in the table below:

Table.2: The possible combinations with the signs

combination	Concentration	Temperature	Time
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	-	-	+
6	+	-	+
7	-	+	+
8	+	+	+

We have 8 possibilities. "+" Indicates high levels (10-3 M for example for concentration or 60 °C for temperature) and "-" indicates low levels (24 hours for immersion time)

2.5.4. Proceed with the experiment

After the determination of the signs + and - we replace them by their values

Table.3: The combinations with the values of the factors

combination	Concentration	Temperature	Time
1	10-6 M	30 °C	24 h
2	10-3 M	30 °C	24 h
3	10-6 M	60 °C	24 h
4	10-3 M	60 °C	24 h
5	10-6 M	30 °C	48 h
6	10-3 M	30 °C	48 h
7	10-6 M	60 °C	48 h
8	10-3 M	60 °C	48 h

III. RESULTS AND DISCUSSION

3.1. Determination of response

For experiment 1, we will determine the level of the inhibitor efficiency with a concentration of 10-6M, a temperature of 30 °C and an immersion time level of 24 h. For experiment 2, we will take a concentration of 10-3 M, a temperature of 30 °C and an immersion time of 24 h and so on. The results obtained are given in Table 4.

Table.4: The combinations with response

combination	Concentration	Temperature	Time	The inhibitor Efficiency %
1	10-6 M	30 °C	24 h	74
2	10-3 M	30 °C	24 h	86
3	10-6 M	60 °C	24 h	72
4	10-3 M	60 °C	24 h	80
5	10-6 M	30 °C	48 h	73
6	10-3 M	30 °C	48 h	82
7	10-6 M	60 °C	48 h	70
8	10-3 M	60 °C	48 h	79

3.2. Analysis of the results

We will carry out 7 analyzes:

- Analysis of the impact concentration
- Analysis of the impact temperature
- Analysis of the impact time
- Analysis of the impact concentration and temperature
- Analysis of the impact temperature and time
- Analysis of the impact concentration and time
- Analysis of the impact concentration, temperature and time

To perform these analyzes, make a few simple calculations.The effect of the concentration factor on our response (The inhibitor Efficiency) can be measured as follows:Sum of ys (responses) with high concentration (10-3 M) divided by 4 (since 4 "+" were used) minus the sum of ys with low concentration (10-6M) divided by 4.

$$\frac{(86+80+82+79)}{4}-\frac{(74+72+73+70)}{4}=9.5$$

We can conclude, for the concentration factor, that when the concentration is at its high value (10-3 M) the inhibitory efficiency increases by 9.5%.

Analysis of the temperature factor gives:

$$\frac{(80+72+79+70)}{4}-\frac{(86+74+82+73)}{4}=-3.5$$

For the temperature factor, that when the temperature is at its high value (60 degrees) the inhibitor efficiency decreases by 3.5%.

Analysis of the time factor gives:

$$\frac{(73+82+70+79)}{4}-\frac{(74+86+72+80)}{4}=-2$$

For the time factor, that when the time is at its high value (48 h) the inhibitor efficiency decreases by 2%.

The time factor has a very small impact on the inhibitor's efficiency and the concentration factor at a greater impact than the other parameters.

For reasons of space we have called the concentration factor A, the temperature factor B and the time factor C. AxB is therefore the combination of concentration and temperature factors.

The results of each combination are simply the mathematical results of the mixture of factors.

Thus, for AxB, the combination of concentration and temperature, the first combination gives "-" for the concentration and "-" for the temperature. The result AxB is "-" x "-" which gives us a "+" and so on.

Table.5: The combinations of the interactions between factors with the signs

combination	Concentration	Temperature	Time	AxB	BxC	AxC	AxBxC
1	-	-	-	+	+	+	-
2	+	-	-	-	+	-	+
3	-	+	-	-	-	+	+
4	+	+	-	+	-	-	-
5	-	-	+	+	-	-	+
6	+	-	+	-	-	+	-
7	-	+	+	-	+	-	-
8	+	+	+	+	+	+	+

Table.6: The combinations of the interactions between factors with the values of the factors

combination	Concentration	Temperature	Time	AxB	BxC	AxC	AxBxC	The inhibitorEfficiency %
1	10-6 M	30 °C	24 h	+	+	+	-	74
2	10-3 M	30 °C	24 h	-	+	-	+	86
3	10-6 M	60 °C	24 h	-	-	+	+	72
4	10-3 M	60 °C	24 h	+	-	-	-	80
5	10-6 M	30 °C	48 h	+	-	-	+	73
6	10-3 M	30 °C	48 h	-	-	+	-	82
7	10-6 M	60 °C	48 h	-	+	-	-	70
8	10-3 M	60 °C	48 h	+	+	+	+	79

Analysis of the AxB combination

$$\frac{(74+80+73+79)}{4}-\frac{(86+72+82+70)}{4}=-1$$

Analysis of the BxC combination

$$\frac{(74+86+70+79)}{4}-\frac{(72+80+73+82)}{4}=0.5$$

Analysis of the AxC combination

$$\frac{(74+72+82+79)}{4}-\frac{(86+80+73+70)}{4}=-0.5$$

Analysis of the AxBxC combination

$$\frac{(86+72+73+79)}{4}-\frac{(74+80+82+70)}{4}=1$$

The effects of the combinations have been grouped in the table 7 and figure 2

Table.7: The effects of the combinations

Factor	effect
Concentration - A	+ 9.5
Temperature - B	- 3.5
Time - C	-2
AxB	-1
BxC	+0.5
AxC	-0.5
AxBxC	+ 1

From the results we notice that the factor with the most influence is concentration. This factor is much higher than the others. Then, the temperature.

Thus, it will be essential to control the concentration and temperature (for example by applying a maximum concentration 10-3M and minimum temperature 30°C) to maximize the inhibitor efficiency.

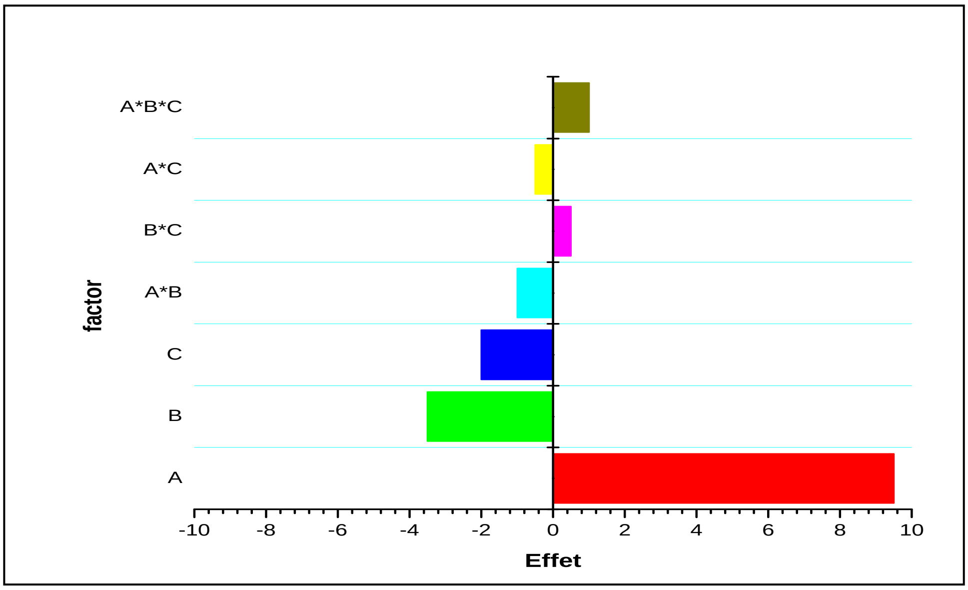

Fig.2: Histogram shows the effect of each combination

IV. CONCLUSION

- 1-allyl-5-nitro-2,7a-dihydro-1H-benzo[d]imidazole-2-thiol is a very good inhibitor in 0.5 M H_2SO_4 .
- The response methodology was used to find out the best conditions by means of 1-allyl-5-nitro-2,7a-dihydro-1H-benzo[d]imidazole-2-thiol as corrosion inhibitor of mild steel in 0.5 M H_2SO_4
- The best conditions for obtaining the maximum inhibitor efficiency are 10^{-3}M of concentration and 30°C of temperature.
- The most influenced factor over others is the concentration.

REFERENCES

[1]. G. Schmitt, Br. Corros. J. 19 (1984) 165.
[2]. A.Y. El-Etre, M. Abdallah, Corros. Sci. 42 (2000) 731.
[3]. H. Shokry, M. Yuasa, I. Sekine, R.M. Issa, H.Y. El-Baradie, G.K. Gomma, Corros. Sci. 40 (1998) 2173.
[4]. Y. Gonzalez, M.C. Lafont, N. Pebere, G. Chatainier, J. Roy, T. Bouissou, Corros. Sci.
[5]. 37 (1995) 1823.
[6]. R. Touir, N. Dkhireche, M. EbnTouhami, M. Lakhrissi, B. Lakhrissi, M. Sfaira, Desalination 249 (2009) 922.
[7]. A. Ghazoui, R. Saddik, N. Benchat, B. Hammouti, M. Guenbour, A. Zarrouk, M. Ramdani, Der Pharm. Chem. 4(1) (2012) 352.
[8]. A. Zarrouk, B. Hammouti, H. Zarrok, R. Salghi, A. Dafali, LhBazzi, L. Bammou, S.S. Al-Deyab,Der Pharm. Chem. 4 (2012) 337.
[9]. Y. Abboud, A. Abourriche, T. Saffaj, M. Berrada, M. Charrouf, A. Bennamar, N. Al Himidi, H. Hannache, Mater. Chem. Phys. 105 (2007) 1.
[10]. A.L. de QueiriozBaddini, S.P. Cardoso, E. Hollauer, J.A. da Cunha Ponciano Gomes, Electrochim. Acta 53 (2007) 434.
[11]. A. Chetouani, M. Douadi, B. Hammouti, T. Ben Hadda, Benkaddour ,Corros. Sci. 48 (2006) 2987.
[12]. K. Tebbji, I. Bouabdellah, A. Aouniti, B.Hammouti, H. Oudda, M. Benkaddour, A. Ramdani, Mater. Letters 61 (2007) 799.
[13]. A.L. de QueirozBaddini, S.P. Cardoso, E. Hollauer, J.A. da Cunha Ponciano Gomes, Electrochim. Acta 53 (2007) 434.
[14]. A. Balezin, S.M. Belen'kii, Yu.P. Aronson, N.M. Belen'Kaya, ZashchitaMetallov 4 (1968) 385.
[15]. R.S. Chaudhary, A. Singh, J. Electrochem. Soc. Ind. 46 (1997) 119.
[16]. K.C. Pillali, R. Narayan, Corros. Sci. 23 (1983) 151.
[17]. B. Donnelly, T.C. Downie, R. Grzeskowiak, H.R. Hamburg, D. Short, Corrs. Sci. 18 (1978) 109.
[18]. T.Sayerh, A. Sghiri, A. Ben Bachir, A. Sayagh, Chratbi, Proc .7th Seic, Seliy, Ferrara, Italy 1 (1990) 241.
[19]. M.T. Makhlouf, S.A. El-Shatory, A. El-Said, Mater. Chem. Phys. 43 (1996).
[20]. H.L. Wang, R.B. Liu, J. Xin, Corros. Sci. 46, 2455–2466 (2004)
[21]. M. ELbakri, R. Touir, M. EbnTouhami, A. Srhiri, M. Benmessaoud, Corros. Sci. 50, 1538–1545 (2008)
[22]. B.D. Mert, M.E. Mert, G. Kardas¸, B. Yazıcı, Corros. Sci. 53, 4265–4272 (2011)
[23]. W. Li, X. Zhao, F. Liu, B. Hou, Corros. Sci. 50, 3261–3266 (2008)
[24]. Y. Elkhotfi, I. Forsal, E.M. Rakib, B. Mernari, Der Pharma. 15 (2016) 160.
[25]. B.Meranari, H. Vezin, M. Lagrenée, Corros. Sci. Volume 44 issue 10 (2002). Page 2271-2289.
[26]. I. Forsal, A. Elyaktini, M. EbnTouhami, B.Mernari, AnalyticalChemistry, An Indian Journal. Vol. 7, Issue 4, 2008.
[27]. M. Scendo, M. Hapel, Corrs. Sci. 49 (2007) 3381.
[28]. M. Scendo, M. Hapel, J. Electroanal. Chem. 613 (2008) 35.

[29]. L. larabi, O. Benali, S.M. Mekelleche, Y. Harek, Appl. Surf. Sci. 253 (2006) 1371.
[30]. D. Kuron, H.-J. Rother, H. Graefen, Werkst. Korros.32 (1981) 409.
[31]. S. Ramesh, S. Rajeswari, Electrochim. Acta 49 (2004) 811.
[32]. A.D. Mercier In :Proccedings of The 5th European Symposium of Corrosion Inhibitors, Ann. Univ. Ferrara (Italie), 1980, P. 553
[33]. I. Forsal, M. EbnTouhami,B. Mernari, J. El Hajri, M. Filali Baba, Electrochim. Acta.28 (2010) 203.

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