INHIBITOR ACTIVITY OF MALEIMIDE AND ITS DERIVATIVES IN MILD STEEL CORROSION IN 1M H_2SO_4

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Abstract: This investigation presents results for the corrosion of mild steel in a 1M H_2SO_4 solution with the addition of maleimide and four of its derivatives. The inhibitory effect of these organic compounds is estimated using a gravimetric method. The calculated values for the corrosion rate, the inhibitor efficiency and inhibitor activity coefficient at the maximum concentration of the organic additive are compared. These studies make it possible to assess the inhibitory properties of these compounds depending on their different functional groups. The obtained results do not represent the studied compounds as good corrosion inhibitors of mild steel in this acidic medium. In view of their practical application, it is necessary to look for opportunities to increase their concentration (over 10^{-3} mol dm^{-3}).

Keywords: mild steel, inhibitors, derivatives of the 1H-pyrrole-2,5-dione, corrosion rate

INTRODUCTION

Mild steel is widely used in many areas of the industrial practice as a construction material in the manufacture of articles with a variety of uses. In many cases, these products are processed in solutions of mineral acids, including sulfuric acid. The purpose of this acid treatment is to clean, degrease, etch the metal surface, etc. (Schmitt, G., *Br.* Corros, Br*., 1984)*. Since acidic media are very aggressive and cause active corrosion, it is necessary to introduce corrosion inhibitors that reduce the rate of process (Sykes, J.M., 1990). Their molecules typically have active centers which allow their adsorption on the metal surface, thus forming a protective layer. A number of organic compounds with different structures and functional groups are proposed as inhibitors. Some of these compounds have oxygen (Lagrenee, M., Mernari, B., Bouanis, M., Traisnel, M & Bentiss, F. , 2002). and nitrogen (Granese, S., Rosales,B., Oviedo, C. & Zerbino, O. ,1992), (Subramanium,G., Balasuramanium, K., & Shridhar, P., 1990), (Stupnisek-Lisac, E., Berkovic,K. & Vorakapic-Furac, J. , 1988), (Raicheva, S., Aleksiev B. & Sokolov, B., 1993) in their molecules. For the corrosion protection of mild steel in 1M H_2SO_4 various organic compounds have been studied and proposed (Eduok,U. & Khaled, M. , 2015), (Yan, L., Zhao, P., Liang, Q & Hou,B. , 2005), (Al-Amiery, A., Kadhum, H., Kadihum, A., Mohamad, B., C. K. How,C. & Junaedi, S. (2014), (Haralanova, T. & Girginov, Ch. , 2015). In this sense, it is of interest to investigate novel organic compounds as inhibitors of mild steel in sulfuric acid. The aim of the present study is to research the inhibitory action of maleimide and some of its derivatives.

EXPERIMENTAL

The investigated samples were made of sheet cold rolled steel with the following composition (mass %): [C] = 0.20; [Mn] = 0.45; [S] < 0.05; [P] < 0.04; [Ni] < 0.3; [Gr] < 0.3; [As] < 0.08 and [Si]= 0.11. The samples were in the form of a disk with a working surface of (9.17 ± 0.01) x 10^{-4} m^2. As corrosive medium a 1M aqueous solution of H_2SO_4 (Merck) was employed.

The inhibitory properties of maleimide ($C_4H_3O_2N$) and its derivatives of ($C_4H_2O_2NR$), where R stands for $-C_6H_5$, $-C_6H_4CH_3$, $-C_6H_4OCH_3$ and $-C_6H_4Br$, respectively, have been studied. The examined compounds are maleimide derivatives, where one hydrogen atom is substituted with different phenyl derivatives. The structural formulae of the five investigated organic compounds are presented in Figure 1.
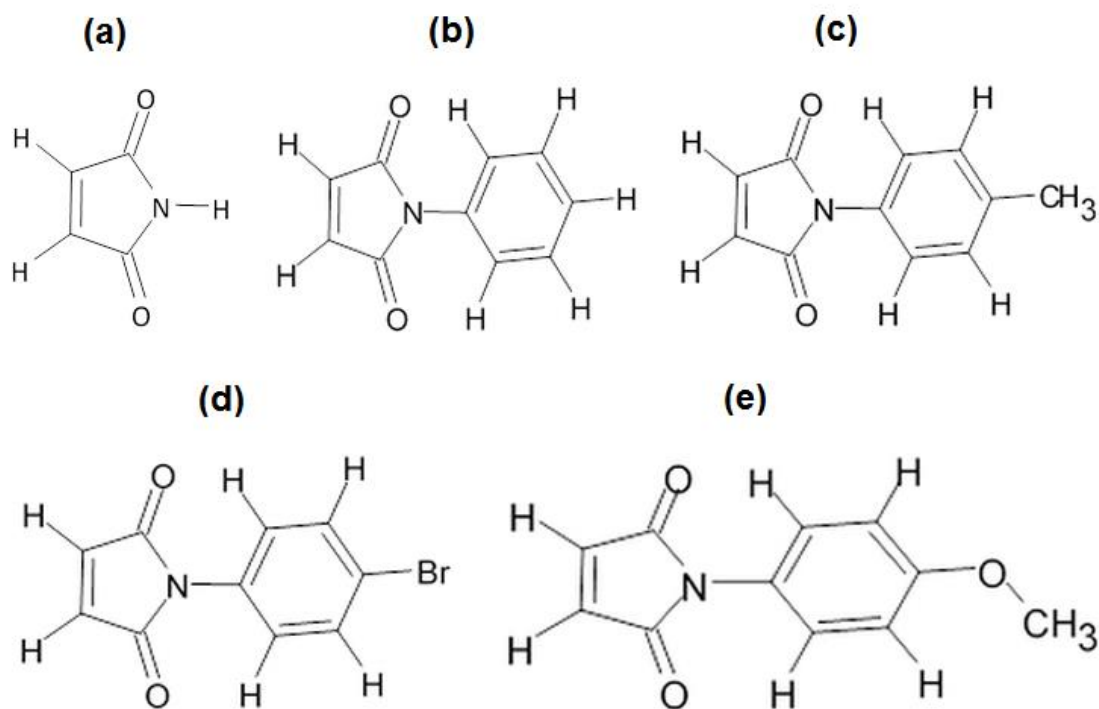

Fig. 1 Structural formulae of the studied inhibitors: (a) 1H-pyrrole-2,5-dione (maleimide) and its four investigated derivatives (b) *1-phenyl-1H- pyrrole-2,5-dione*, (c) 1-(4-methylphenyl)-1H-pyrrole-2,5-dione, (d) *1-(4-methoxyphenyl)-1H- pyrrole-2,5-dione* and (e) *1-(4-bromophenyl)-1H-pyrrole-2,5-dione*

The concentration of the substances was varied within the limits $5 \times 10^{-5} \div 10^{-3}$ mol dm^{-3}. All experiments were carried out in laboratory conditions, at room temperature (20±1°C). The investigation of the inhibitory effect of maleimide and its derivatives were performed by using a gravimetric method (Chiang, K. & Mintz, T. ,2008), (Mingpeng, Z., Kaiming, W., Yuemin, D. & Bensheng, Z. , 1994). The corrosion rate (k), the inhibitor efficiency (Z) and inhibitor activity coefficient (Y) were calculated.

RESULTS AND DISSCUTION

The mild steel specimens were exposed to the corrosion medium (1 M H_2SO_4) for 48 hours with varying the inhibitor concentration within the range of $5 \times 10^{-5} \div 10^{-3}$ moldm^{-3}. It was found, for all investigated organic substances, that the increase in their concentration increased leads to an enhancement of their inhibitory action. Some principal parameters characterizing the corrosion process were calculated:

Corrosion rate (k):

$$k = \frac{m_0 - m}{S \times t} \left[g\, m^{-2} h^{-1} \right], \tag{1}$$

where $m_0 \left[g \right]$ and $m \left[g \right]$ express the weight of the metallic sample before and after the experiment; $S \left[m^2 \right]$ stands for the sample surface area and $t \left[h \right]$ is the exposure duration (48 h).

Inhibitor efficiency $\left(Z \right)$:

$$Z = \frac{\left(k_0 - k \right)}{k_0} \times 100 \left[\% \right],$$

(2)

where with k_0 and k are designated the corrosion rates of the metal in the corrosive environment without and with the addition of an organic compound inhibitor, respectively.

Inhibitor activity coefficient $\left(Y \right)$:

$$Y = \frac{k_0}{k}.$$

(3)

The calculated values for k, Z and Y for the maximal concentration (10^{-3} mol dm^{-3}) of the added organic compound are presented in Table 1.

Table 1. Values for the corrosion rate $\left(k \right)$, inhibitor efficiency $\left(Z \right)$ and inhibitor activity coefficient $\left(Y \right)$ at the maximal concentration of the organic compound

Inhibitor		$k \left[gm^{-2}h^{-1} \right]$	$Z[\%]$	Y
(a)	1H-pyrrole-2,5-dione	1.168	10.33	1.11
(b)	1-phenyl-1H-pyrrole-2,5-dione	0.956	26.60	1.36
(c)	1-(4-methylphenyl)- 1H-pyrrole-2,5-dione	0.841	35.50	1.55
(d)	1-(4-methoxyphenyl)- 1H-pyrrole-2,5-dione	0.878	32.60	1.48
(e)	1-(4-bromophenyl)- 1H-pyrrole-2,5-dione	0.956	26.65	1.35

The comparison of the obtained values indicates that the most significant inhibitory effect exhibits 1-(4-methylphenyl)-1H-pyrrole-2,5-dione. Overall, the obtained values for the parameters of the corrosion process represent maleimide and its four derivatives as substances having comparatively unsatisfactory protective properties for mild steel corrosion in 1 M H$_2$SO$_4$. This is most probably due to their insignificant solubility in aqueous media, and hence the impossibility of achieving higher concentrations. However, since the studied group of substances posses active functional groups, possibilities for their introduction into the corrosive environment with higher concentrations could be sought. One approach in this regard is the use of their solutions in ethyl alcohol or acetone.

CONCLUSIONS
➤ The performance of such investigations is of particular interest in view of the fact that the inhibitory properties of the organic compounds can be experimentally determined depending on the presence of different functional groups.
➤ The influence of the functional group in maleimide derivatives was studied and 1-(4-methylphenyl)-1H-pyrrole-2,5-dione was found to have the best protective effect.

➢ Notwithstanding the presence of active groups, the investigated compounds are not suitable for inhibiting corrosion in acidic media on mild steel.

Acknowledgements

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