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CORROSION INHIBITION OF LOW-CARBON STEEL IN A 0.1 M H_2SO_4 MEDIUM

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Abstract: *In the present work, preliminary studies on the corrosion of low carbon steel in sulfuric acid medium with the addition of the organic substance 6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]isochromene-1,3-dione were performed. Its introduction into the corrosive medium (0.1M H_2SO_4) was carried out by its solution in ethanol. The gravimetric method was applied to determine the characteristics of the corrosion process. The corrosion rate, the degree of protection and the inhibition action coefficient were estimated by varying the concentration* $\left(5\times10^{-7}-5\times10^{-5}\right) mol\, dm^{-3}$ *of the inhibitor substance.*

The obtained results clearly show that this compound has the potential to successfully be employed as an effective corrosion inhibitor of low carbon steel in sulfuric acid media. However, due to its low solubility in ethanol, experiments have been performed to find other suitable polar solvents to enable the increase of its concentration in the corrosive environment.

Keywords: low-carbon steel, corrosion, inhibitors, acidic media, *6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]isochromene-1,3-dione*

INTRODUCTION

The study of the theoretical foundations and characteristics of corrosion processes on steels is of great practical importance. Suffice it to note that the vast majority of all engineering solutions are based on the use of details made of steel. In this sense, the successful corrosion protection of the embedded steel products is of great importance. On the basis of comprehensive and in-depth investigations of the nature of corrosion phenomena, increasingly more effective methods for their corrosion protection have been and are still being developed. It is known that the use of suitable inhibitors is one of the most widely used approaches to successfully combat corrosion of steels in acidic environments. Numerous studies have shown that a number of organic chemical compounds introduced in insignificant amounts in aggressive corrosive environments reduce significantly the rate of the corrosion process, thus substantially reducing its harmful effects. Considerable progress has been made in recent years in developing new and effective corrosion inhibitors. It is worth noting that the inhibitory protection of steel is also definitely cost effective. Its application usually does not disrupt the established technological regimes and almost does not require the use of additional equipment.

Due to its heterogeneous composition and specific structure, low carbon steel is characterized by poor corrosion resistance in mineral acid media. The protective action of inhibitors is associated with changes in the state of the metallic surface, as well as in the kinetics (Haralanova, T. et al., 2015, 2016, 2017, 2018) of the partial reactions causing the corrosion process. A huge number of organic compounds have been investigated as inhibitors of acid corrosion (Ebenso, E. E. & Oguzie, E. E., 2005, Wei, H., Heidarshenas, B., Zhou, L., Hussain, G., Li, Q. & Ostrikov, K., 2020). The use of corrosion inhibitors of steel in such media has widely been investigated for the oil industry (Finšgar, M., Jackson, J., 2014)

Preliminary results for the inhibitory effect of *6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]isochromene-1,3-dione* on the corrosion of low carbon steel in sulfuric acid medium are reported in the present study.

EXPERIMENTAL

The investigated samples were cut of sheet steel 3, type *EN-S235J2*. The specimens were in the shape of a parallelepiped with a work surface of $\left(30.01 \pm 0.01\right) \times 10^{-4} m^2$.

The experiments were performed in a corrosive medium, consisting of 0.1M sulfuric acid solution at constant temperature (25°C). The sulfuric acid used to prepare the contact solution (0.1M H_2SO_4) was supplied by "Merck".

The effect of the concentration of the inhibitor *6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]isochromene-1,3-dione* on the corrosion rate, the degree of protection and the coefficient of inhibition was studied. The structural formula of the tested organic compound is given in Figure 1. The inhibitor was dissolved in ethanol and introduced into the corrosive medium in the form of an ethanol solution. The exposure of all tested samples in the corrosive environment was for 54 hours.

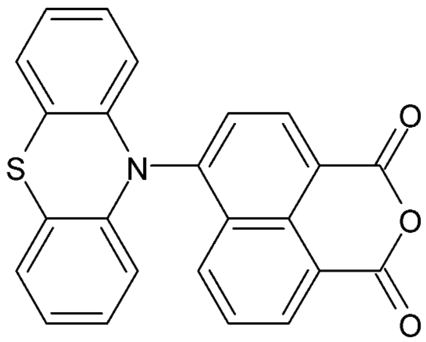

Fig. 1. Structural formula of the studied organic inhibitor
6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]isochromene-1,3-dione

All experiments were performed in laboratory conditions. In order to study the inhibitory effect a conventional gravimetric method (Chiang, K., Mintz, T., 2008) was used. It is worth noting that this method provides real information only about the corrosion rate, but not about the action mechanism of the inhibitor on the corrosion process.

The concentration of the inhibitory substance was varied in two orders of magnitude $\left(5 \times 10^{-7} - 5 \times 10^{-5}\right) moldm^{-3}$. Reference samples (in the absence of inhibitor) were also tested for comparison.

RESULTS AND DISCUSSION

The studies performed enabled to successively determine the corrosion rate (k), the efficiency of the inhibitor (Z) and the coefficient of inhibitory action (Y).

- **Corrosion rate** (k) can be calculated using the expression:

$$k = \frac{(m_0 - m)}{St}\left[gm^{-2}h^{-1}\right],$$

where m_0 and m is the mass $[g]$ of the steel before and after the experiment, respectively; $S\left[m^2\right]$ is the surface of the sample and $t[h]$ is the exposition time of the samples (54 h) in the corrosive medium (0,1 M H_2SO_4).

In order to evaluate the efficiency of the investigated inhibitor, two magnitudes were calculated:

- **Degree of protection** (Z): $Z = \frac{(k_0 - k)}{k_0} \times 100[\%]$,

where k_0 is the corrosion rate of the tested steel in the corrosive medium in the absence of inhibitor, and k is the respective rate after the addition of the organic inhibitory substance.

- **Inhibition action coefficient** (Y): $Y = \frac{k_0}{k}$.

The results obtained from the laboratory tests are presented in Table 1.

Table 1. Corrosion rate (k), degree of protection (Z) and inhibition action coefficient (Y) values for different concentrations of the organic additive

$C\left[moldm^{-3}\right]$	0.0000	5×10^{-7}	1×10^{-6}	5×10^{-6}	1×10^{-5}	5×10^{-5}
$k\left[gm^{-2}h^{-1}\right]$	1.7523	1.7032	1.6558	1.6079	1.5593	0.8815
$Z[\%]$	-	2.80	5.51	8.24	11.01	49.69
Y	-	1.03	1.06	1.09	1.12	1.99

For a more informative presentation of the obtained results, Figure 2 graphically presents the dependencies of the corrosion rate (k) and the degree of protection (Z) on the concentration of the organic substance.

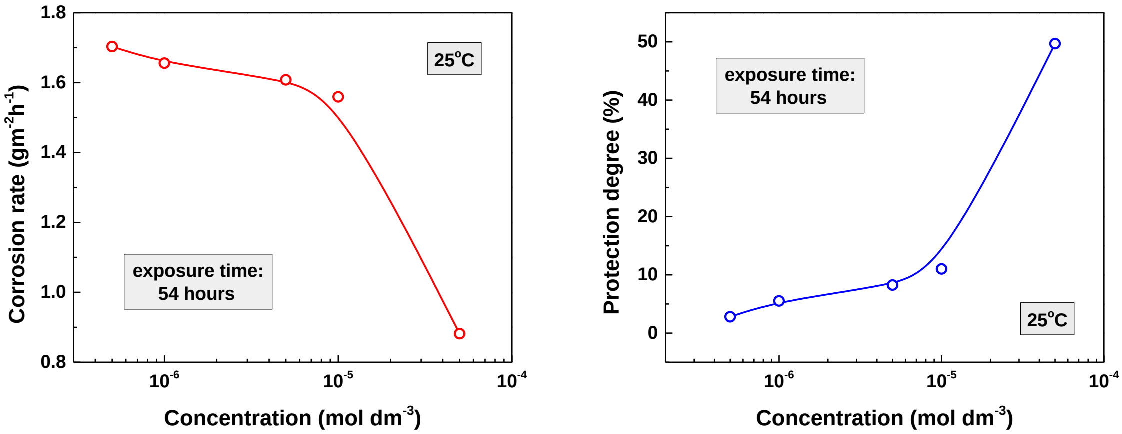

Fig. 2. Dependence of the corrosion rate (a) and degree of protection (b) on the concentration of organic inhibitor

The literature review clearly shows that the most effective inhibitors of acid corrosion of steels are aromatic compounds containing N, O and complex bonds in their molecule. The investigated substance is a representative of this class of organic compounds. The obtained results show that the corrosion rate logically decreases with increasing concentration of the organic compound, and at the maximum value of its concentration $C = 5\times10^{-5}\left[moldm^{-3}\right]$ the degree of protection $\left(Z\right)$ strongly increases.

The results clearly show *6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]-isochromene-1,3-dione* can serve as an effective corrosion inhibitor of steels in sulfuric acid media. Unfortunately, this substance is slightly soluble in ethanol and is practically insoluble in water. In this regard, preliminary experiments have been carried out to find a suitable solvent by which this inhibitor can be introduced into acidic corrosive media.

CONCLUSION

1. The studied organic substance *6-(10H-phenothiazin-10-yl)-1H,3H-benzo[de]isochromene-1,3-dione* exhibits good inhibitory properties against the corrosion of low carbon steel in sulfuric acid medium.
2. By means of a gravimetric method, data were obtained on the corrosion rate, the efficiency of the inhibitor and the coefficient of inhibitory action by varying its concentration.
3. The obtained results confirm the fact that aromatic compounds containing N, O and complex bonds in their molecule are good inhibitors of steel in mineral acid media.
4. In preliminary studies, a suitable solvent for the tested organic compound was sought, in order to an approach for its introduction with higher concentrations in aggressive acidic media.

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