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ORGANIC COMPOUNDS AS INHIBITORS FOR MILD STEEL IN 1 M H_2SO_4

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Abstract. The inhibitory effect of two organic compounds has been studied: 2-(4-cyanophenyl)-1-oxo-1H-inden-3-yl acetate and 2-(4-fluorophenyl)-1-oxo-1H-inden-3-yl acetate on samples of Steel 3 in 0.1 M H_2SO_4. Using gravimetric analysis the corrosion rate, the inhibitor efficiency and its protective effect coefficient have been determined. All experiments are carried out varying the substance concentration in the interval (10^{-6} - $2x10^{-5}$ mol dm^{-3}), at 25 ± 1°C. The study of the inhibitors' performance was assessed in stationary corrosion state. The estimated values of the parameters characterizing the corrosion processes demonstrate a satisfactory inhibitory effect of the investigated substances.
Keywords: corrosion, steel 3, organic compounds, inhibitors

Introduction

The corrosion of metals is an undesirable spontaneous natural process. It causes significant losses as a significant number of manufactured metal products become unusable. The corrosion processes are also related to environmental pollution due to leakage of hazardous industrial and domestic waste. Nowadays, the corrosion remains a significant global issue which requires a constant search for and implementation of various protection methods. The processes related to corrosion and the methods of protection continue to be the subject of unrelenting theoretical and applied interest.

One of the most effective methods to reduce the aggressiveness of the corrosive liquid/ gas media is the use of inhibitor protection. A number of organic compounds (Ochao et al., 2004; Shalaby & Osman, 2001; Quraishi & Sardar, 2003) are known to be applicable as corrosion inhibitors for steel in acidic media. The most investigated corrosion media are chloride containing solutions (Wang et al., 2003; Mathiyarasu et al., 2001; Rajendran et al., 1998) and those of sulfuric acid (Ebenso, 2003; Haralanova & Girginov, 2014; Haralanova et al., 2014; Oguzie, 2004; Oguzie et al., 2004; Umoren et al., 2008). Such compounds typically contain nitrogen, oxygen, phosphorus or sulphur in a conjugated system and function via adsorption of the molecules on the metal surface in order to block the active sites, thus decreasing the corrosion rate (Wang et al., 2003). The effect of the adsorbed inhibitor is to protect the metal from the corrosive medium (Quraishi & Sardar, 2003).

The aim of this work is to study the inhibiting effect of two organic compounds on the corrosion of steel in acidic environment.

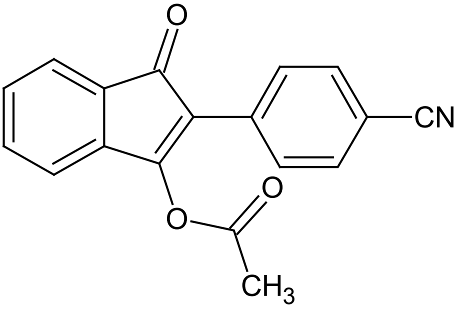
Experimental

The investigations were carried out with Steel 3 samples, in the shape of plates with a surface area of 2 x10^{-3} m^2. The composition (Haralanova & Girginov,2014) of the steel samples (wt. %) is: [C] 0.16; [Mn] 0.65; [S] < 0.05; [P] < 0.04; [Ni] < 0.3; [Gr] < 0.3; [As] < 0.08; [Si] 0.05 - 0.15.

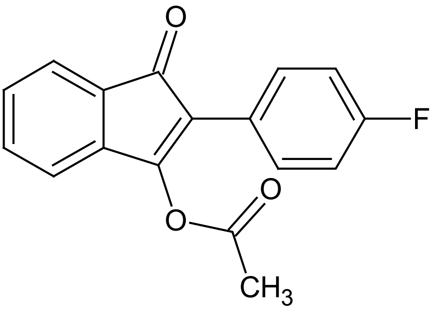
A 1 M H_2SO_4 aqueous solution was used as a corrosion medium (Umoren et al., 2008) (Merck). The inhibitory action of two organic compounds: 2-(4-cyanophenyl)-1-oxo-1H-inden-3-yl acetate and 2-(4-fluorophenyl)-1-oxo-1H-inden-3-yl acetate was studied, varying their concentration in the interval (10^{-6} - 2x10^{-5} mol dm^{-3}). These substances are synthesized in the laboratory of the Department "Chemistry and Chemical Technologies" of the Ruse University "Angel Kanchev", Subsidiary in Razgrad (Prof. N. Stoyanov). All experiments were conducted in a constant-temperature corrosive environment at 25 ± 1°C. The corrosion resistance of the steel samples was evaluated using classic gravimetric analysis.

Results and discussion

The structural formulae of the organic inhibitor molecules are as follows:



2-(4-cyanophenyl)-1-oxo-1*H*-inden-3-yl acetate



2-(4-fluorophenyl)-1-oxo-1*H*-inden-3-yl acetate

The conducted preliminary studies show that a stationary value of the corrosion rate (K) is reached after 20 hours. This time value is reached in 0.1 M H_2SO_4, and at a concentration of the inhibitor C = 1x10^{-5} [mol dm^{-3}].

An evaluation of the corrosion resistance of steel in certain compositions of the medium is made by calculation of three quantitative parameters (Ochao et al., 2004; Oguzie et al., 2004; Haralanova et al., 2014). All results are then compared with those obtained in absence of inhibitor (Shalaby & Osman, 2001).

The corrosion rate (K) obtained using the gravimetric analysis is calculated:

$$K = \frac{(m_0 - m)}{St} \, [g\, m^{-2} h^{-1}], \tag{1}$$

where with m_0 [g] is denoted the weight of the sample before its submission to the corrosion environment, m [g] is the weight of the metallic sample after the experiment, S [m^2] is the surface area of the sample and t [h] is the exposure time. The dependency of the corrosion rate on concentration is plotted in Fig. 1.

The inhibitor efficiency (Z) could be ascertained by the follow equation:

$$Z = \frac{K_0 - K}{K_0} \times 100[\%], \tag{2}$$

where K_0 is the corrosion rate of the metal without inhibitor and K is its corrosion rate in the presence of organic inhibitor. The obtained experimental data are presented in Fig. 2.

From the obtained experimental data on the corrosion rate in the absence (K_0) and in the presence (K) of an inhibitor, the inhibitor's protective effect coefficient (Y) can easily be determined:

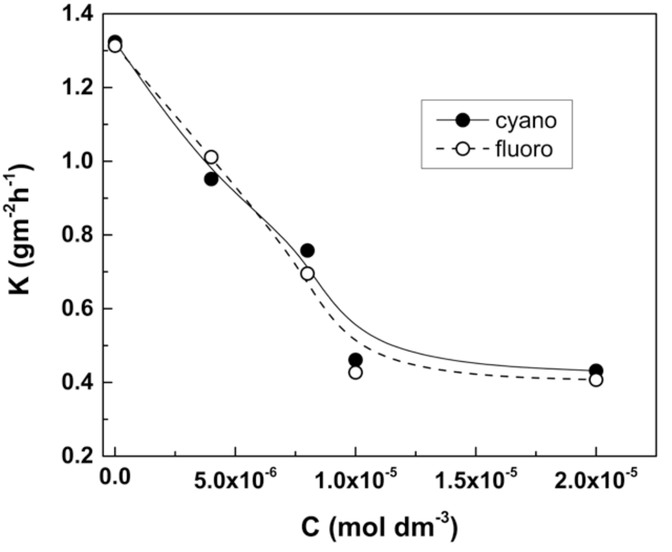


Fig. 1. Rate of corrosion (*K*) depending on the concentration of organic inhibitors in 0.1 M H_2SO_4 (25°C)

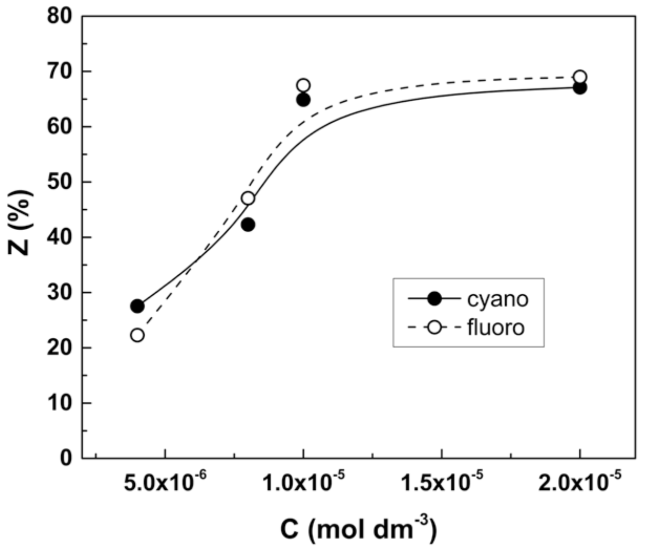


Fig. 2. Dependency of the degree of protection (Z) on the corrosion inhibitor concentration in 0.1 M H_2SO_4 (25°C)

$$Y = \frac{K_0}{K} \quad (3)$$

The calculated values for *Y* are given in Fig. 3.

The obtained results for the characteristics of the corrosion processes are logical. With increasing concentration of the inhibitor in sulfuric acid solution, the corrosion rate of the steel sample decreases, and accordingly both the inhibitor efficiency (Z), as well as the coefficient of the protective effect of the inhibitor (Y) grows. On the other hand with increasing the concentration of the inhibiting organic compound, the rate of corrosion (*K*) of the steel decreases, but after a certain value of the concentration: 2x10^{-5} mol dm^{-3} it practically remains constant.

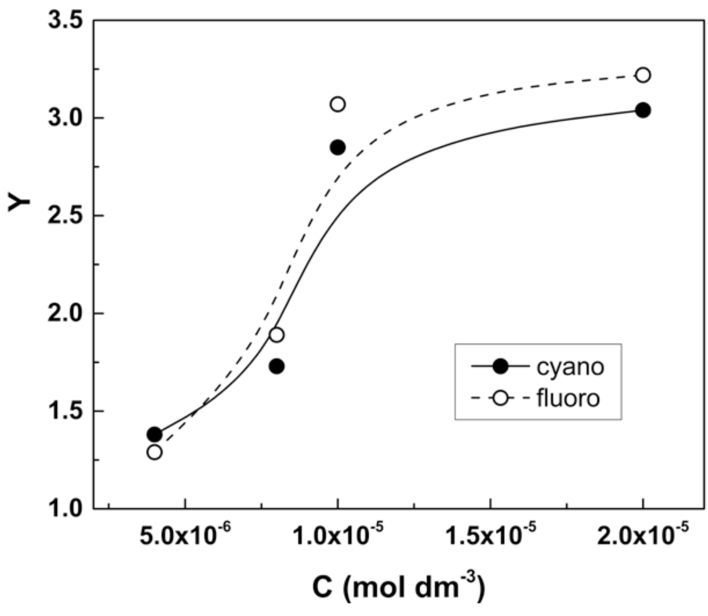


Fig. 3. Protective effect coefficient (*Y*) vs. concentration of organic inhibitor added to 0.1 M H_2SO_4 (25°C)

Conclusion

The conducted preliminary studies have shown that the substances 2-(4-cyanophenyl)-1-oxo-1*H* inden-3-yl acetate and 2-(4-fluorophenyl)-1-oxo-1*H*-inden-3-yl acetate added to 0.1 M H_2SO_4 decrease the corrosion rate of samples from Steel 3. As a result of their addition, the values of the inhibitor efficiency and the protective effect coefficient for both inhibitors considerably increase. Practically both inhibitors have the same effect on the corrosion process, despite the difference in their composition (cyano/fluoro). This is due to their identical structural configuration. The fact that the studied compounds noticeably reduce the aggressiveness of the corrosion environment, identifies them as promising inhibitors for the protection of works, made out of this type of steel. In order to obtain additional information, further studies using modern electrochemical methods have been planned.

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