

**EVALUATION OF THE EFFECTIVENESS OF TWO-COMPONENT
INHIBITORS BASED ON POLYELECTROLYTES**

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This paper presents the results of gravimetric determination of the protection degree provided by two-component corrosion inhibitors and a quantitative assessment of the effectiveness of a mixed inhibitor. The influence of various factors on inhibitor effectiveness was investigated. It has been established that two-component inhibitors effectively protect carbon steels from corrosion at high temperatures.

Due to the tightening of environmental protection requirements, quantitative forecasting methods have shown the ineffectiveness of protecting metals with individual chemical compounds, which sharply limits the range of previously known inhibitors [1]. Therefore, the development of environmentally friendly, low-toxicity, multi-component inhibitors is becoming increasingly relevant. Promising inhibitors of this kind are mixtures containing compounds capable of forming self-organizing surface layers [2]. Currently, special attention worldwide is paid to the creation of new polyfunctional inhibitors that prevent chemical, electrochemical, microbiological corrosion and scaling, with their environmental safety being important. In industrially developed countries, a number of multifunctional inhibitors based on phosphorus-containing compounds have been developed and are in use:

derivatives of phosphoric and phosphonic acids, organophosphonates, and their compositions with polyelectrolytes and complexes with metal ions.

The most promising are organic reagents, among which phosphorus compounds based on phosphonic acid derivatives occupy a primary place. These compounds possess a number of unique properties, one of which is the ability to form sparingly soluble compounds under certain conditions [3]. Organic corrosion inhibitors are substances of mixed action; they slow down both the cathodic and anodic reactions of the corrosion process [4].

This work investigated two-component type inhibitors based on polyelectrolytes and phosphorus-containing compounds [5,6]. The studies were conducted in background solutions of the following composition: 5% Na₂SO₄ + 3% H₂SO₄ (BG-1) and in a neutral medium (BG-2). Electrodes were made of St.3 steel with the composition (%): Fe=98.36; C=0.20; Mn=0.50; Si=0.15; P=0.04; S=0.05; Cr=0.30; Ni=0.20; Cu=0.20. In gravimetric experiments, steel samples in the form of plates sized 3.0 × 3.0 × 0.1 cm were used, treated with SiC abrasive paper of grades 320, 400, and 600, respectively. The objects of study were sodium carboxymethyl cellulose (NaCMC), hydrolyzed polyacrylonitrile (HPAN), Unifloc and their mixtures with PMFA (piperidine-1-ylmethylenephosphonic acid), NPMP (3-nitrophenyl piperidine 1-yl methylenephosphonic acid), 1-(phenyl diazo) 2,4-propargyl resorcinol ether (SHA-25).

Experimental work was conducted to determine the corrosion rate of the working electrode in saline media in the presence of the studied inhibitors at various concentrations and ratios within a certain temperature range using the gravimetric method. To obtain an averaged result, each experiment was performed three times to ensure accuracy. The inhibition coefficient and the degree of protection (%) were calculated using the equations:

$$\gamma = \frac{i_c}{i_c'} \quad (1); \quad Z = \frac{i_c - i_c'}{i_c} * 100\% \quad (2)$$

where i_c and i_c' the corrosion currents in the absence and presence of the inhibitor, respectively. The corrosion rate (i_c) was determined by the following equation:

$$i_c = \frac{P * n * 26,8}{S * \tau * A}; \Gamma * \frac{A}{\text{cm}^2} \quad (3)$$

P - weight loss of the electrode, g; n - metal valence; 26.8 - Faraday's number; S - electrode area, cm²; τ - test duration, hours; A - atomic mass of the metal.

The results of determining the corrosion rate, inhibition coefficient, and degree of protection of steel by NaCMC with heterocyclic derivatives in different background solutions depending on the inhibitor concentration. The table shows that inhibitors based on heterocyclic derivatives exhibit slightly greater inhibitory ability. With an increase in inhibitor concentration, their protective ability increases up to a concentration of 30 mg/l,

and thereafter changes insignificantly. With an increase in the medium temperature, the inhibitory ability of NaCMC and heterocyclic derivatives also increases, indicating an intensification of chemisorption processes. Inhibitors Na-CMC and its mixtures with PMFA, NPMP, SHA-25 were used at concentrations from 10 mg/l to 30 mg/l.

These compounds possess a number of unique properties, one of which is the ability to form sparingly soluble compounds of polymeric structure under certain conditions. Containing both an amino group and a phosphonic acid residue, these compounds have broad practical potential for use as complexones and analytical reagents. According to experimental data, among the individual inhibitors, SHA-25 exhibits the greatest effect on the steel corrosion rate at 20°C, but the studied individual inhibitors are not highly effective, with the highest protective effect reaching only 81.51% at 20°C and 93.12% at 60°C (Table 2). Such results allow us to conclude that these inhibitors chemically interact with the steel surface, and a process of chemical adsorption is observed, as evidenced by the increase in the degree of protection with increasing temperature.

A quantitative assessment of the effectiveness of the mixed inhibitor compared to the individual components was carried out based on calculations of their mutual influence coefficient (synergism parameter):

$$\chi^{\Sigma} = \gamma^{\Sigma} / \prod \gamma_i = \prod \chi_i, \quad (4)$$

where $\gamma^{\Sigma} = K_0 / K^{\Sigma}$ and $\gamma_i = K_0 / K_i$ are the corrosion inhibition coefficients of steel by the inhibitor; K^{Σ} is the corrosion rate in the presence of the mixed inhibitor, K_i is the corrosion rate in the presence of only one of its components [4]. Research has shown that at 20°C and pH=8, the compositions PAMBFK-HPAN at an equimolar ratio were the most effective. For the PAMBFK-HPAN and PAMBFK-NaCMC systems, a high synergistic effect is also observed at an equimolar ratio, although somewhat lower than in the first case [5].

Comparison of the obtained data shows that the effectiveness of the developed two-component systems based on derivatives of aminomethylenephosphonic acids slightly exceeds the effectiveness of systems based on polyphosphates and exhibit chemisorption properties.

References

1. Bouayed M., Rabaa H., Srhiri A., Saillard J.Y., Ben Bachir A., Le Beuze A. Experimental and theoretical study of organic corrosion inhibitors on iron in acidic medium // Corros. Sci. - UK, 1999, -Vol. 41 –pp. 501-509.
2. Kholikov A.Zh., Akbarov Kh.I. Influence of two-component inhibitors on steel corrosion in various reservoir waters // Khimicheskaya Promyshlennost'. -Saint Petersburg, 2014. -Vol.91. -No.6. -P.37-43. (In Russ.)

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3. A.M.Levina. Synthesis and anticorrosive properties of some aminomethylenephosphonic acids // *Novye Khimicheskie Tekhnologii: Proizvodstvo i Primenenie*. - Penza, 2009. - P.35-37. (In Russ.)

4. Kholikov A.J. Phisico-chemical properties of alkylaminomethylenephosphonate inhibitors // *Austrian Journal of Technical and Natural Sciences*. -Vienna (Austria), 2015. - No.11-12. -P.68-71.

5. Akbarov Kh.I., Rashidova K.X., Azimov L.A. Development of two-component corrosion inhibitors based on polyelectrolyte and heterocyclic compounds // *Universum: Khimiya i Biologiya*. Russia, 2019. -No.11(65). –P. 43-47 (In Russ.)