INHIBITION OF ALUMINIUM ALLOY CORROSION BY COMPOSITIONS BASED ON SODIUM ALGINATE AND ZINC SALTS IN CHLORIDE-CONTAINING MEDIUM

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The inhibitory effect of compositions based on sodium alginate and zinc salts on the corrosion of an aluminum alloy in a chloride-containing environment was studied. It was found that the effectiveness of protection largely depends on the nature of the anion in the zinc salt composition. The highest corrosion resistance (96%) was demonstrated by the composition with zinc acetate, which is due to the formation of a dense film with improved protective properties.

Keywords: aluminum alloy, corrosion, chloride-containing medium, inhibitory composition, sodium alginate, zinc sulfate, zinc nitrate, zinc acetate, anti-corrosion efficiency, adsorption

Introduction. Due to the successful combination of physical and mechanical properties, aluminium alloys are often used in many industries, including aviation, oil and gas, chemical, construction, and transport. However, under the influence of aggressive environments, they are subject to localised corrosion [1]. In order to prevent it and increase the service life of aluminium alloys, inhibitor protection is usually used. Polysaccharides derived from plant materials are known to be effective corrosion inhibitors for aluminium alloys [2–6]. In particular, alginates derived from brown algae [7-8]. Anionic residues of inhibitors play an important role in anti-protection of metals. It has been found that some anions can form protective films on the alloy surface, while others can promote passivation or act as complexing agents [9-10]. Therefore, the aim of the study is to investigate the corrosion inhibition of aluminium alloy in a chloride-containing medium by sodium alginate compositions with zinc salts having different anionic compositions.

Materials and methods. Samples of aluminium alloy AA2024 with the following chemical composition (wt %) were studied: 90.8.94.7 A1, 3.8...49 Cu, 1.2...1.8 Mg, 0.3...0.9 Mn, 0.5 Si, up to 0.5 Fe, up to 0.3 Zn. The corrosive medium was a 0.1% NaCl solution, to which a natural polysaccharide, sodium alginate (structural formula $(C_6H_7O_6Na)_n)$) and salts: zinc sulfate ($ZnSO_4$), zinc nitrate ($Zn(NO_3)_2$), zinc acetate $(CH_3COO)_2Zn)$ were added as corrosion inhibitors. To inhibit the medium, compositions with an equal ratio of components with a constant total concentration of 1 g/l were used. The test was performed at room temperature 20 ± 2ºC. Sodium alginate, zinc sulphate, zinc nitrate, and zinc acetate were purchased from SPHERE SIM LLC.

The electrochemical behaviour of the samples in the corrosive and inhibited solutions was studied by the method of potential-dynamic polarisation using a

VersaStat 3 potentiostat/galvanostat (AMETEK Scientific Instruments), a saturated Ag/AgCl reference electrode and an auxiliary platinum electrode. The potential scanning rate was 2 mV/s. The working area of the sample was 1 sm^2 Before immersion in the corrosive medium, the samples were treated with abrasive paper, grades P320 and P600, and degreased with acetone. The corrosion current density was determined from polarisation curves using the graph-analytical method. The effectiveness of corrosion inhibitors was evaluated by the degree of protection η *(%)* which was determined by the formula: $\eta = 100\%\ (i_1 – i_2)/i_1$ where i_1 and i_2 mA/sm² are the corrosion current density in the uninhibited and inhibited solutions, respectively.

Results and discussion. Fig. 1 shows the polansation curves of the alloy after 24 h of exposure in a 0.1% NaCl solution without and with the addition of compositions based on sodium alginate. It was established that the highest values of cathodic and anodic corrosion currents of metal corresponded to the sample kept in a solution without an inhibitor. With the addition of a composition based on sodium alginate and zinc sulphate, the polarisation current density in both the anodic and cathodic regions decreases, indicating inhibition of both electrochemical corrosion processes. At the same time, the degree of metal protection, determined by the corrosion current density, is satisfactory and amounts to 83% (Table 1). When using a composition containing sodium alginate in combination with zinc nitrate, the decrease in anodic current density is more significant, which indicates a higher efficiency of the protective film formed on the metal surface. The maximum degree of metal protection (96%) was achieved using a composition based on sodium alginate and zinc acetate. Such differences in the inhibition of aluminium alloy corrosion can be explained by the influence of the nature of the anion in the composition of zinc salts, which are part of the composition with sodium alginate. In particular, acetate ions interact with aluminium ions to form carboxylate complexes that promote the formation of a dense film with improved protective properties. In the case of nitrate ions, the inhibitory effect is achieved by thickening the natural passive oxide layer, which further protects the metal from corrosion [9]. Sulphate ions, on the other hand, can interact with the alloy surface to form less stable sorption layers that do not provide sufficient barrier protection [10].

Table 1. Electrochemical characteristics of AA2024 alloy after 24 hours exposure in control and inhibited solutions

Solution	E_{corr}, V	i_{corr}, mA/cm^2	η, %
0.1% NaCl solution	-0,5	$1{,}48 \cdot 10^{-6}$	-
0.1% NaCl solution + composition based on sodium alginate and zinc sulphate	-0,45	$2{,}58 \cdot 10^{-7}$	83
0.1% NaCl solution + composition based on sodium alginate and zinc nitrate	-0,42	$1{,}02 \cdot 10^{-7}$	93
0.1% NaCl solution + composition based on sodium alginate and zinc acetate	-0,42	$5{,}32 \cdot 10^{-8}$	96

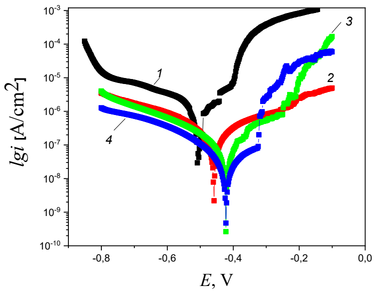

Fig. 1. Polarization curves of the alloy after 24 h of exposure in 0.1% NaCl solution without (1) and with the addition of an inhibitor: 2 – sodium alginate and zinc sulfate in a ratio of 1:1, 3 – sodium alginate and zinc nitrate in a ratio of 1:1, 4 – sodium alginate and zinc acetate in a ratio of 1:1.

Conclusions. According to the results obtained, the protective effectiveness of compositions based on sodium alginate and zinc salts against corrosion of aluminium alloy in a chloride-containing solution significantly depends on the nature of the anion included in the zinc salt. The most effective composition was found to be zinc acetate, which provided a degree of protection of 96%.

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