Anti-corrosion protection of aluminum alloy by composition based on polysaccharide and sorbate

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Abstract – The inhibition of corrosion of duralumin alloy by natural polymer guar gum was investigated. It was found that the effectiveness of its corrosion inhibition in 0.1% sodium chloride solution is significantly increased by its combination in one composition with the potassium salt of sorbic acid which is confirmed by the results of electrochemical impedance studies and data of X-ray energy dispersion microanalysis.

Keywords – corrosion, duralumin alloy, chloride solution, guar gum, sorbic acid, electrochemical impedance spectroscopy, scanning electron microscopy.

Introduction

Al-Cu-Mg alloys find extensive use in the aeronautical, automobile, railway, shipbuilding, and construction industries due to their low density and high strength. However, they are susceptible to local corrosion caused by differences in electrochemical properties of intermetallic inclusions and the aluminium matrix. Corrosion inhibitors are one of the most effective means of anti-corrosion protection of aluminium alloys. Traditional inhibitors are synthesized using expensive and toxic chemicals. They pollute the environment and are difficult to dispose of. Environmentally safe "green" corrosion inhibitors from raw plant materials, particularly natural polysaccharides, are a good alternative to synthetic inhibitors [1]. In particular, it was established that guar gum (GG), a natural water-soluble nonionic polysaccharide extracted from the seeds of the guar plant Cyamopsis tetragonolobus,effectively slows the corrosion of steel in acidic environments.However, as it was previously shown [2], the effectiveness of aluminium alloy corrosion inhibition by this biopolymer is insufficient in a neutral chloride environment. Therefore, in this work, an attempt was made to strengthen the protective effect of GG on an aluminium alloy,AA2024-T3, in a sodium chloride solution by combining it in one composition with the potassium salt of sorbic acid (PS).

Methods

Corrosion inhibition of AA2024-T3 aluminum alloy was studied in a 0.1% sodium chloride solution, to which GG and PS were added separately and in the form of their mixture. The methods of electrochemical impedance spectroscopy (EIS), scanning electron microscopy and energy dispersive X-ray analysis (EDX) were used.

Discussion of results

It was established (Fig. 1) that the impedance module of an aluminium alloy at a current frequency of 0.1 Hz (Z_{01}) in a corrosion solutionincreased by 10–12 timesunder the influence of the GG+PS inhibitor mixture. Adding guar or potassium sorbate to the corrosion environment does not significantly increase the value of Z_{01}. The formation of two-time constants (Fig. 1) can be observed in the frequency dependences of the phase angle of the alloy, which can be attributed to the electrochemical processes of corrosion on the metal surface and the formation of an organic surface film. The shift of the maximum dependence of phase angleto the range of higher frequencies of 100–1000 Hz and its increase after adding the mixture of inhibitors to the solution indicates the formation of an effective protective adsorption film on the metal. The impedance spectra were modeled with EIS Spectrum Analyzer program, a two-time constant equivalent circuit was used [3]. A considerable increase in the metal charge transfer resistance R_{ct} and the surface film resistance R_f in the environment inhibited by the GG + PS mixture was established, which was maximal when the ratio of its components was equal. Based on the EIS results, the inhibitory efficiency of the studied composition on aluminium alloy in chloride solution is 94%.

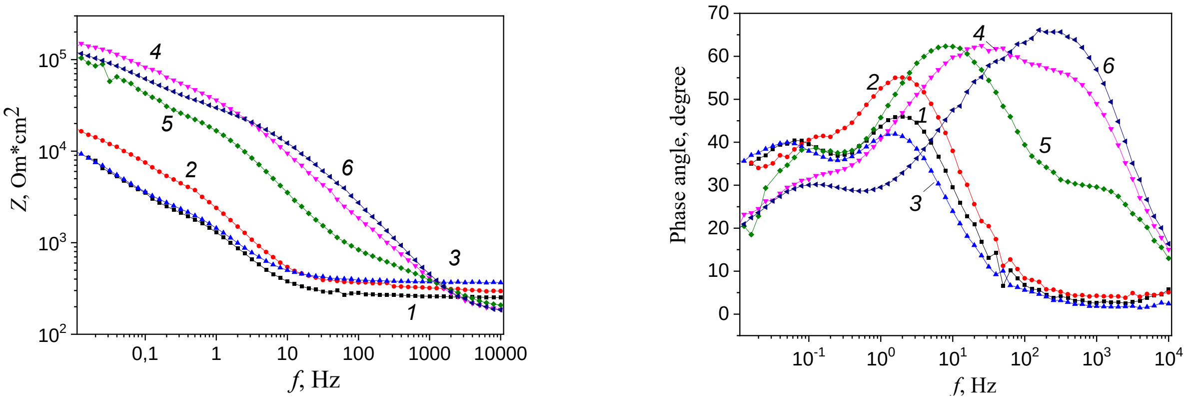

Fig.1. Bode plots of AA2024-T3 alloy in 0.1% NaCl solution (1)
inhibited with 2 g/l of GG (2); 2 g/l of PS (3); 2 g/l of GG + PS (1:1 ratio) (4);
2 g/l of GG + PS (1:3 ratio) (5); 2 g/l of GG + PS (3:1 ratio) (6)

EDX results confirm the formation of an organic protective layer on the surface of the alloy (Table 1) The components of the inhibitor mixture are adsorbed on the surface of the aluminum alloy, sealing its natural oxide film. Presumably, the formation of poorly soluble complex compounds of biopolymer and sorbate with aluminum and copper cations also occurs.

Table 1

EDX analysis data of the surface of the aluminium alloy after 7days
of exposure to the solution

Solution	element mass, %						
	O	C	Al	Mg	Mn	Fe	Cu
0,1 % NaCl	7,51	35,39	47,02	1,38	0,78	0,71	7,21
2 g/l of GG + PS (1:1 ratio)	14,58	11,78	66,13	1,20	0,60	0,36	5,35

Conclusion

Thus, an environmentally safe inhibiting composition based on equal amounts of guar gum and potassium sorbate has increased protective properties on an aluminium alloy in a neutral sodium chloride solution due to the formation of an adsorption protective film on the surface of the metal and the sealing of the oxide layer. The anti-corrosion efficiency of the composition exceeds 90%, which makes it promising for industrial use.

References

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