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CYSTEINE AND MODIFIED CYSTEINE AS GREEN CORROSION INHIBITORS OF ALUMINUM ALLOY

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Abstract:

In its pure form, aluminum is easy to process and has a high level of corrosion resistance. However, due to its low strength, the possibility of application of pure aluminum is reduced. When alloyed, aluminum alloys are widely used material in construction, different industries, airspace and military. Commercial 7000 series aluminum alloys commonly have zinc and magnesium as the main alloying element, and often also contain copper. This 7000 series of aluminum alloys offer a very high strength after heat treatment. The life time of these alloys is reduced due to corrosion damage. It is known that corrosion directly or indirectly affects materials, human health and safety, and it causes global economic and environmental problems. The use of inhibitors in corrosion protection is the simplest, most economical and most efficient approach that is routinely used to 'reduce' this problem in industry. The most widely used inorganic inhibitors, such as chromates, are not safe, causing health and safety problems due to their toxicity. Organic compounds have increased interest of the scientific community as potential inhibitors in exchange for the most commonly used. The aim of this study was to investigate new green, eco-friendly inhibitors from the group of amino acids and their combination with lanthanides. For the purposes of this investigation, cerium-cysteine complex was synthesized and analyzed by Fourier Transform Infrared spectroscopy (FTIR), Optical Microscope (OM), Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM / EDS), Potentiostatic Electrochemical Impedance Spectroscopy (PEIS) and Linear Sweep Voltammetry (LSV) analyses. SEM/EDS was used for morphological analysis and to determine the composition of the aluminum alloy on which the electrochemical tests have been performed. Electrochemical measurements (PEIS, LSV) were performed in order to test the inhibitory efficacy in 0.1M NaCl at room temperature. Different concentrations of cysteine and Ce-cysteine complex were examined to optimize the process. The adsorption of the inhibitor follows the Langmuir isotherm, and based on the electrochemical results and calculated thermodynamic potential (Gibbs free energy) it can be concluded that both cysteine and cerium-cysteine complex are mixed type of inhibitors. It can be concluded that both cysteine and Ce-cysteine complex inhibitors satisfactory inhibition effect on aluminum alloy corrosion.

Experimental:

- Metal specimen 7000 series aluminum alloy in form of 15x20mm and 5mm thickness.
- Corrosive medium 0.1M NaCl

Results:

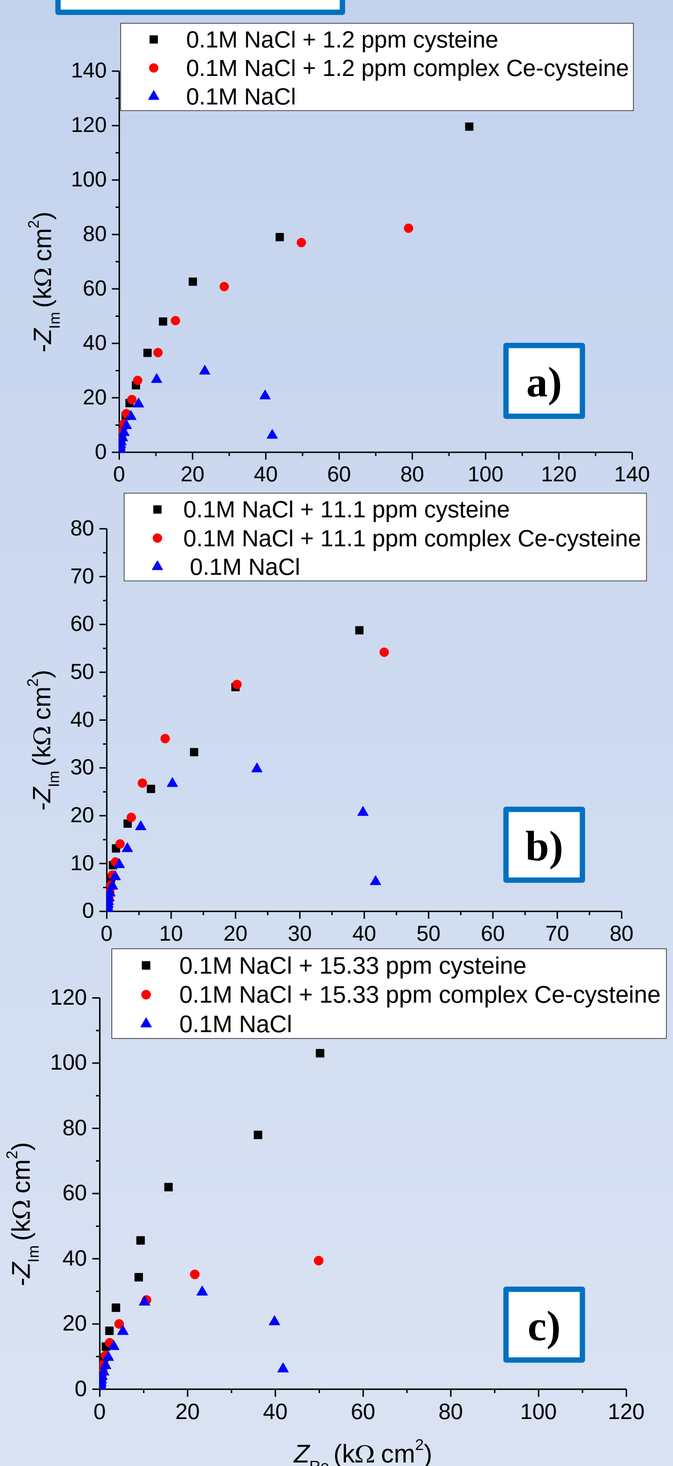

Figure 1. Nyquist plot for 7000 series of aluminum alloy in 0.1 M NaCl (pH=5.6) without and with inhibitors: a) 1.2 ppm of inhibitors, b) 11.1 ppm of inhibitors, c) 15.33 ppm of inhibitors.

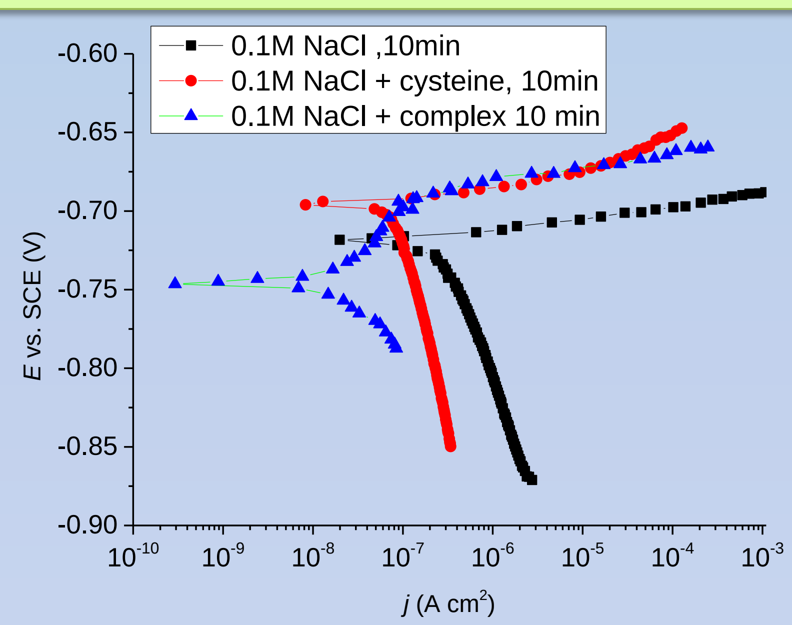

Figure 2. Potentiodynamic polarization plot for AA7000 serie in 0.1 M NaCl in the absence and presence of inhibitors cerium-cysteine complex and cysteine.

Table 1. A chemical composition of metal specimen, mass%:

Zn	Cu	Mg	Cr	Si	Mn	Al
7.35	1.66	1.92	0.26	0.12	0.25	88.44

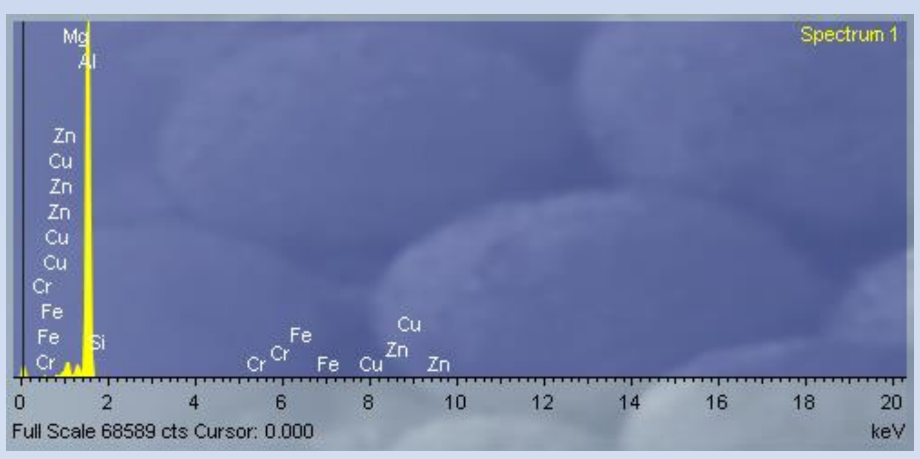

Figure 3. EDS spectrum of metal specimen 7000 series aluminum alloy

Figure 4. Optical Microscope picture of metal specimen in a) 0.1M NaCl + 3mM cysteine, b) 0.1M NaCl + 3mM complex, c) 0.1M NaCl.

Table 3. Thermodynamic parameters in 0.1M NaCl in presence of inhibitors, on 7000 series aluminum alloy, at 298K.

inhibitor	*C*, ppm	*K*ads	Δ*G*ads kJ/(molK)
complex	1.15	1.9175	-11.5638
cysteine		1.1669	-10.3333
complex	11.1	0.1527	-5.2955
cysteine		0.2072	-6.0514
complex	15.3	0.0107	1.2894
cysteine		0.1906	-5.8438

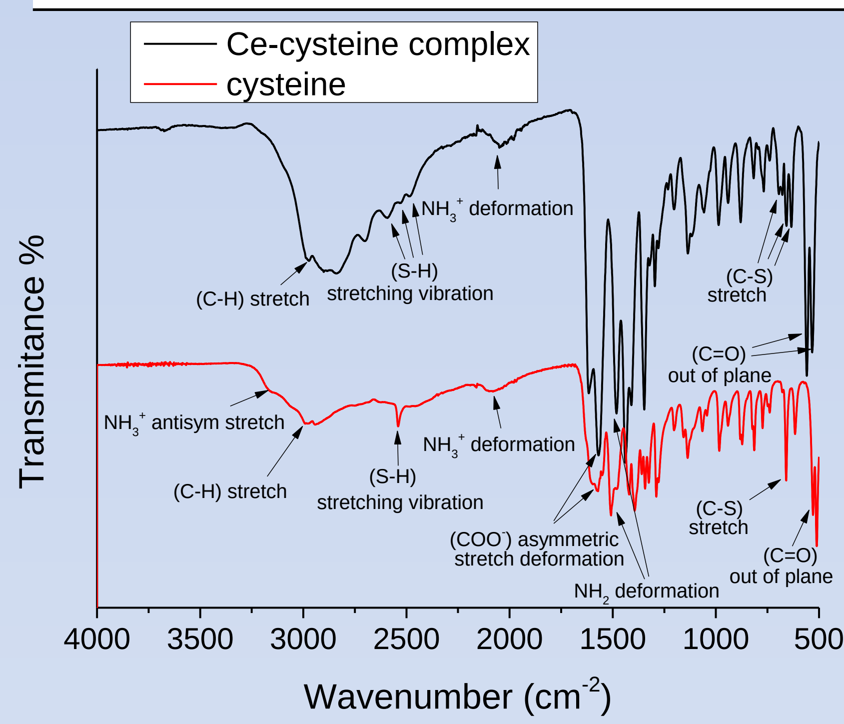

Figure 5. FTIR spectrum of synthetized cerium-cysteine complex and cysteine.

Conclusions:

From the obtained results the following can be concluded:

- Cerium-cysteine complex as well as cysteine act as a good corrosion inhibitor for 7000 series aluminum alloy in corrosive medium
- Both cerium-cysteine complex and cysteine are mixed type of inhibitors
- Kinetic calculations show that adsorption takes place mainly by physisorption.

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