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EIS Characterization of Passive Films Formed on $Al_xCoCrFeNi$ Alloys

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Abstract:
Electrochemical Impedance Spectroscopy (EIS) measurements have been performed on High Entropy Alloys (HEAs) type $Al_xCoCrFeNi$ with different aluminium content (x = 0.6; 0.8 and 1.0) in order to characterize their passive film and corrosion resistance at 37ºC under simulated physiological conditions (Ringer´s solution) acidulated with HCl at pH=3. The impedance spectra were obtained at different potential values between E_{corr} and + 0.7 V vs. SCE.

Analysis of the impedance spectra was done by fitting the experimental data to different equivalent circuits. Two equivalent circuits, with one time constant and two time constants respectively, can be satisfactory used for fitting the spectra: one time constant represents the characteristics of the passive film and the second one is for the charge transfer reactions.

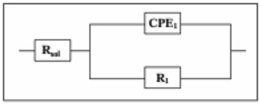
The polarization resistance and the double layer capacity were compared at different polarization potentials for the detection of the passive film structure and the roughness of the electrode surface.

It can be seen for both materials that the resistence of the passive film is very high and decreases slightly with the potential: the very high resistance of the passive film implies a high corrosion resistance which can be attributed to the formation of the protective oxide layer.

There is a decrease in the values of the parameter n of the CPE (constant phase element used in the mathematically modelling in order to consider also the electrochemical behavior of systems which do not correspond exactly to a pure capacitance) related to the rugosity of the electrode surface.

Keywords: high entropy alloys, aluminium, EIS, equivalent circuit, corrosion resistance, passivation, Ringer solution.

a)



b)

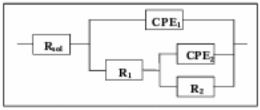


Figure 1: Figure illustrating the equivalent ciruits used for the fitting of the experimental data where R_{sol} is the ohmic resistance of the electrolyte. a) The first circuit has one time constant.

b) The second equivalent circuit fitted for HEAs in Ringer's solution of pH = 3 presents the second time constant which illustrates the slight porosity of the passive layer on the alloy surface (R_1 and CPE_1). So, the equivalent circuit contains in addition a parallel circuit for charge transfer reactions through the passive layer consisting of the double layer capacitance CPE_2 and charge transfer resistance R_2.

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