Electrochemical Studies of Aluminium and Aluminium Silicon Alloys in 0.1 mol. L⁻¹ H₂SO₄

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Introduction

The aluminium alloys have been developed to produce materials with better properties than pure Al for specific purposes such as automobiles, aviation, containers, and electronic devices¹. Al-Si alloys are the most used non-ferrous alloys because of their low density, high corrosion resistance, ease of casting, low-thermal expansion coefficient and a wide range of mechanical properties². For these reasons, studies on the corrosion and the electrochemical behavior of Al and its alloys have attracted the attention of many investigators. In the present work, corrosion potential, potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques are applied to study the electrochemical behavior of Al and Al-Si alloys in solution of H₂SO₄.

Experimental

The working electrodes employed were made of Al, (Al + 0.3% Si) and (Al + 0.7% Si). These electrodes were provided from the Research Group of Materials Engineering at the Federal University of Pará (UFPA). Pt grade and a saturated sulfate electrode (SSE) were used as auxiliary and reference electrodes, respectively and the experiments were carried out in solution of H_2SO_4 (0.1 mol.L⁻¹ at 25^oC). The corrosion potential, potentiodynamic current–potential and EIS measurements were carried out using a Potentiostat/Galvanostat (Gamry Instruments). Analysis time of the corrosion potential was one hour for working electrodes. The polarization curves were obtained in the range -1.5 - +1.5 V at a scan rate of 5 mV / s. Data from electrochemical impedance spectroscopy (EIS) were obtained in the frequency range from 10 kHz to 0.1 Hz, 10 times readings per decade logarithmic amplitude voltage 7mV.

Results and Discussion

The corrosion potential (E_{corr}) variations under open circuit condition (OCP) with time graphs recorded in 0.1 mol.L⁻¹ H₂SO₄ solution for all the three types of specimen, are shown in Fig.1. The steady Ecorr measured after one hour of exposure for all the investigated specimens. The corrosion potential (E_{corr}) at open circuit potential (OCP) of Al-Si alloys shows a considerable shift (~100 mV) in the positive potential region if compared to Al³.

Fig. 2 represents typical potentiodynamic anodic and cathodic polarization curves recorded for Al, (Al + 0.3% Si) and (Al + 0.7% Si). Passivation phenomenon (current density of approximately 1.0 mA cm⁻²) was observed in potentiodynamic anodic polarization measurements to Al and Al-Si alloys. This constant value of electric current and the shape of polarization curves indicate the formation of a layer of aluminum oxide on the surface of the electrodes. The similarity in the shapes of the cathodic and anodic curves also shows that the electrochemical processes that occur at the interface metal/oxide/electrolyte are identical to the electrodes of Al and Al-Si³.

The data reveal that each impedance diagram (Fig. 3) consists of a large capacitive loop at high frequency (HF) and a small inductive one at low frequency (LF) values.

The HF capacitive loop could be assigned to the relaxation process in the natural oxide film covering the surface of the three Al samples and its dielectric properties and the inductive loop may be related to the relaxation process obtained by adsorption and penetration of SO_4^{2-} ions on and into the oxide film⁴.



Fig. 1. E_{corr} variations with time for Al, (Al + 0.3% Si) and (Al + 0.7% Si) in H_2SO_4 (0.1 mol.l⁻¹ at 25^oC).



Fig. 2. Potentiodynamic anodic and cathodic polarization curves recorded for Al, (Al + 0.3% Si) and (Al + 0.7% Si) in H_2SO_4 (0.1 mol.1⁻¹ at 25^oC).



Fig. 3. EIS response for Al, (Al + 0.3% Si) and (Al + 0.7% Si) in H_2SO_4 (0.1 mol.1⁻¹ at 25⁰C).

Conclusion

Al, Al-Si (0.3%) and Al-Si (0.7%) alloys were investigated by E_{corr} variation with time, potentiodynamic polarization, and EIS techniques. Additions of silicon to aluminium becomes more positive the corrosion potential (~100 mV). Potentiodynamic polarization indicated that the silicon no has a significant influence on anodic oxide formation. The analysis of EIS showed that capacitive loop and inductive loop decreased, this suggests that corrosion is affected by silicon.

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