

ELECTROCHEMISTRY & CORROSION of PLATINUM DURING CONSISTENT PULSES POLARIZATION

Aleksandr PIKELNY

Alfred E. Mann Foundation
28460 Avenue Stanford, Valencia, CA 91355
E-mail: spikelny@aemf.org

INTRODUCTION

Platinum electrodes are used for manufacturing medical and biomedical devices, such as an implantable biomedical stimulator [1]. Due to this device must provide lifetime service, corrosion behavior of materials, used in their production, play the critical role. This is also important, because of electrical impulses, which can accelerate corrosion and corrosion failure. Usually these stimulation impulses have charge-balanced waveforms [2].

The goal of our work was to investigate the electrochemical behavior of platinum parts of these devices and evaluate their corrosion performance.

EXPERIMENT

Electrochemical measurements (potentiometry, cyclic voltammetry and chronopotentiometry) and samples-electrodes (indifferent and stimulation) described in [1, 3].

Corrosion tests with using an in-house built internal circuit, which provides capacitively coupled monophasic electrical pulses to working electrodes, also described in [3]. At "low" polarization indifferent electrode was powered by consistent pulses of cathodic current 110 mA/sq.cm during 500 μ s (55 μ C/sq.cm) and anodic current 1.4 mA/sq.cm with the duration corresponding to the same amount of electricity (55 μ C/sq.cm) as in the first impulse and recess to the total time 100 ms. The corresponded stimulation electrode was polarized by anodic current 210 mA/sq.cm during 500 μ s (105 μ C/sq.cm) and cathodic current 2.6 mA/sq.cm with the duration, corresponding the same amount of electricity as during the anodic impulse and recess to whole cycle time 100 ms. At "high" polarization electrodes were powered by the pulses twice bigger amplitude: cathodic current 220 mA/sq.cm (110 μ C/sq.cm) for indifferent electrode and anodic current 420 mA/sq.cm (210 μ C/sq.cm) for stimulation respectively (with the duration of the impulses 500 μ s). Amplitude of the recharge current was the same as for "high" polarization: anodic current 1.4 mA/sq.cm for indifferent electrode and cathodic current 2.6 mA/sq.cm for stimulation electrode. Amount of electricity (110 μ C/sq.cm and 210 μ C/sq.cm) and recess to whole cycle time 100 ms were also the same.

The samples were tested at the temperatures of 37°C and 87 °C. All potentials are given versus Ag/AgCl reference electrode.

RESULTS AND DISCUSSION

Cyclic voltammetry measurements, in potential range starting from -650 mV to 1150 mV, show two peaks of hydrogen adsorption-desorption and one peak of oxygen reduction current during reverse potential scan.

According to the Semerano Criterion, which values close to the unity, all these peaks have adsorption nature. Increasing of the temperature resulted in decreasing the hydrogen peaks and increasing of the peak, corresponding to the oxygen reduction.

Electrode pairs were subjected to continuous stimulation at the "low" and "high" polarization conditions for a period of more than 6 months at the "low" and "high" temperature (37 and 87°C).

Average potentials of the indifferent electrode at the 37°C after a one-week transition period was 0.815 and 0.810 V for "low" and "high" polarization respectively. At the 87°C their values were 0.330 and 0.315 V. On the stimulation electrode these potentials were lower: 0.085 and 0.097 V at 37°C and -0.239 and -0.196 V at 87°C. Oscilloscopic chronopotentiometric measurements demonstrate a potential's delay at 0.1-0.05 V observed during the cathodic current. This potential corresponds to the platinum oxides reduction peak on the cyclic voltammograms. The duration of this potential delay increased for the first week of polarization and periodically changed during the test period. Fluctuations of the average potential were consistent with this time duration.

On the basis of the solution analysis, a corrosion rate of platinum was estimated in the range of 0.9 mg/sq.m*h and less.

A possible mechanism of platinum corrosion in our conditions is connected with the formation and reduction of platinum oxides and local acidification of the solution caused by the impulses of current.

REFERENCES

1. A. Pikelny and J. Schulman, in *Meeting Abstracts*, PV 2000-1, Abstract No. 201, The Electrochemical Society, Toronto, Canada (2000).
2. J. C. Lilly, J. R. Hughes, E. C. Alvord Jr., and T. W. Galkin, *Science*, **121**, 468 (1955).
3. A. Pikelny, J. Schulman and M. Helland, in *Meeting Abstracts*, PV 2001-1, Abstract No. 130, The Electrochemical Society, Washington, DC (2001).