

EVALUATION PLATINUM PLATED TITANIUM ELECTRODES FOR MEDICAL DEVICES APPLICATION

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INTRODUCTION

Platinum widely used as an electrode material for medical and biomedical devices. One of them is an implantable biomedical stimulator [1]. Despite good electrostimulation properties, platinum has poor mechanical characteristics. In contrast, titanium and its alloys have suitable mechanical, but poor electrical and electrostimulation parameters. Therefore platinum plating can improve electrical characteristics of titanium and extend its application for medical devices manufacturing.

The goal of our work was to evaluate the process of platinum plating on titanium and its alloys and investigate their electrochemical and corrosion behavior and performance.

EXPERIMENT

Corrosion and electrochemical experiments, equipment and samples described in [2].

EIS measurements were provided on the Gamry FAS1 Femostat Potentiostat controlled by a personal computer with company electrochemical analysis software.

Platinum was plated from Midas Platinum Solution (Rio Grande) [3]. Despite titanium surface treatment widely described in literature [4 - 6], it was developed our own technique.

Corrosion tests with using an in-house built internal circuit, which provides capacitively coupled monophasic electrical pulses to working electrodes, also described in [2]. Couple "stimulation"- "indifferent" electrodes was powered by consistent pulses of cathodic (toward stimulation electrode) current 130 mA/sq.cm and anodic (toward indifferent electrode) current 96 mA/sq.cm during 500 μ s. Recharge current on stimulation electrode (anodic 2.9 mA/sq.cm) and indifferent electrode (cathodic 2.2 mA/sq.cm) has duration corresponding to the same amount of electricity (65 μ C/sq.cm for stimulation and 48 μ C/sq.cm for indifferent electrode) as in the first impulse with big amplitude. Electrodes were polarized with the frequency 40 pulses per second.

Electrochemical tests were run in the temperature range from 25°C to 87 °C. Corrosion tests were at the temperature 87 °C.

RESULTS AND DISCUSSION

At the all range of temperature, cyclic voltammetry measurements in potential range starting from -650 mV to 1150 mV, were similar as well for bare platinum as for plated parts. It was clearly observed two peaks of hydrogen adsorption-desorption at -0.45...-0.55 and -0.35...-0.50 V with one peak of oxygen reduction at -0.10 V (versus Ag/AgCl electrode). According to Semerano Criterion all these peaks have adsorption nature. By

integrating the cathodic peak area and using the known value of hydrogen adsorption on platinum 220 μ C/sq.cm at 25°C [7], roughness coefficient was estimated in the range of 1.9 for bare platinum and up to 2.6...30 for plated parts.

Increasing of temperature results in decreasing hydrogen peaks and increasing oxygen peak. Last effect can be correlated with the positive shift of the potential scan reverse, which results in deeper platinum oxidation.

At the same conditions of polarization cyclic voltammograms on the titanium electrode have different shape and, what more important, in the order of magnitude less current value than platinum. These phenomena were used to distinguish platinum from titanium. We can also admire that low values of roughness coefficient are caused by noncontinuous platinum deposit.

Plated at different conditions electrode pairs (stimulation - indifferent) along with bare platinum electrodes were subjected to continuous stimulation from internal power source at 87°C. Performance of the electrodes was evaluated by periodical examination of their cyclic voltammograms and calculation real electrode area. It was observed some decreasing (20...60%) of electrodes functioning in first three weeks and stable properties on future experiments for five months.

On the basis of the solution analysis, a corrosion rate of platinum was estimated in the range of 0.2 to 1.4 mg/sq.m*h and less.

Average potentials of the indifferent and stimulation electrodes after a few transition weeks stabilized approximately at the 0.2 and 0.35 V respectively. Chronopotentiometric measurements show the potential's shift during the impulses with the amplitude up to 1.5 V (depending of polarization intensity) from average in negative and positive directions for stimulation and indifferent electrodes respectively. According to the Pourbaix diagram, platinum at these potentials and pH should be in the immunity state. Impulses of the current resulted in continuous change of the electrode surface from totally oxidized to hydrogen adsorbed. A possible mechanism of platinum corrosion in our conditions is associated with the formation and reduction of platinum oxides and local acidification of the solution caused by the impulses of current.

REFERENCES

1. A. Dupont, S. D. Bagg, J. L. Creasy, C. Romano, G. E. Loeb and F. J. R. Richmond, in *IFESS 2001 Processing*, p.7, Cleveland, Ohio (2001).
2. A. Pikelny, J. Schulman and M. Helland, in *Meeting Abstracts*, PV 2001-1, Abstract No. 130, The Electrochemical Society, Washington, DC (2001).
3. WWW.RIOGRANDE.COM
4. ASTM B481-68 (Reapproved 1997).
5. L. A. Mikhailova, E. V. Kasatkin, V. E. Kasatkin and S. G. Prutchenko, in *Russian Journal of Electrochemistry*, Vol. 36 No. 8, p. 866-873, (2000).
6. M. Paunovic and M. Schlesinger, *Fundamentals of Electrochemical Deposition*, John Wiley & Sons, Inc., (2000).
7. J. Giner, J. M. Parry, S. Smith and M. Truchan, *J. Electrochem. Soc.*, **116**, 1692, (1969).