ELECTROCHEMICAL & CORROSION BEHAVIOUR IMPLANTABLE BIOMEDICAL STIMULATORS

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INTRODUCTION

One of the novel medical devices is an implantable (injectable) biomedical stimulator [1]. These devices powered from external RF or internal battery and provide chronical stimulation to patient. Ideal scenario intends their lifetime service, which rise problems of reliability and possible failure due to corrosion and degradation.

Injectable microstimulators, designed by the company have size in thousands times less than conventional pacemaker, what make problems more difficult.

This device produces electrical impulses, which can give a possibility of corrosion of external parts. This is not only stimulation electrode, but return (indifferent) electrode too. Indifferent electrode, in contrary with pacemaker, has size and area compare to stimulation one.

Small internal volume with high-density parts package inside raises problems with unit hermeticity and water penetration and generation. High levels of electric and magnetic fields especially with moisture as electrolyte can cause internal corrosion and final failure.

The goal of our work was to investigate the performance devise as whole unit and the electrochemical behavior of external platinum parts and evaluate their corrosion performance.

EXPERIMENT

Performances of fully assembled units were tested simultaneously in a fixture, powered by the RF field. Parameters of experiment were selected on the most severe level of stimulations. Each unit was placed in a separate vessel with Phosphate Buffered Saline (pH 7.4 from SIGMA) and monitored during the experiment. For processes acceleration tests were performed at elevated temperature 87°C. Once a week temperature was resumed to 37°C and solution level was corrected with NERL high purity water. Units performance were evaluated by comparison electrical parameters before and after the test.

Electrochemical and corrosion experiments techniques and equipment described in [2].

Electrochemical tests were run in the temperature range from 25°C to 87°C, corrosion measurements at 37°C and 87°C.

RESULTS AND DISCUSSION

Electrochemical behavior of platinum in working solution was similar in all temperature range. It was observed two peaks of current of hydrogen adsorption-desorption and one peak of oxygen reduction. Increasing temperature results in decreasing hydrogen peaks and in increasing oxygen peak. All these peaks have adsorption nature.

Corrosion tests were provided by using an in-house built internal circuit, which provides capacitively coupled monophasic electrical pulses to working electrodes. Parameters of polarization were selected similar to units, operated via RF field. At the current 130 mA/sq.cm charge injection per phase on stimulation electrode was 65 μC/sq.cm. After test solutions were analyzed on platinum contents and on the base of these analysis corrosion rate was estimated less than 0.9 mg/sq.m*h (0.37 μm/ear).

Average potentials of the indifferent and stimulation electrodes after a one-week transition period stabilized approximately at the –0.2 and –0.5 V (Ag/AgCl) respectively. Chronopotentiometric measurements show the potential’s shift during the impulses 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 of platinum [3] at these potentials and pH, the metal should be in the immunity state. A possible mechanism of platinum corrosion in conditions of polarization can be linked with the formation and reduction of platinum oxides and local acidification of the solution caused by the impulses of current.

REFERENCES

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