Analysis of the time dependence of the platinum electrode open-circuit potential in blood serum

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Since the 1920s, a significant number of publications has been dedicated to the problem of measurement of redox potential (RP) in biological media. It should be noted that the term "open-circuit potential" (OCP) is a more accurate electrochemical descriptor of the quantity measured. Generally, this value is interpreted as an integral indicator of the antioxidant/prooxidant system balance in the organism. Most work in this area was focused on finding correlations between changes in OCP and various pathological states of the organism, as well as with the partial pressure of oxygen (pO_2) or levels of toxic "middle molecules" in blood.

However, the use of outdated measurement methodologies imposes significant limitations on the reliability and predictive power of the method. *I.e.*, the overwhelming majority of investigators report only discrete values of OCP of the working electrode in the biological medium, usually giving no indication of the duration of electrode contact with the medium. The goal of the present work was to analyze the time dependence of the potential of the platinum electrode immersed in blood serum.

The measurement of the changes of platinum electrode OCP in the course of its immersion in the investigated medium (blood serum) was recorded on an IPC-Compact computer-controlled potentiostat (Volta Co. Ltd, Russia) against an Ag/AgCl reference electrode. Prior to each measurement the platinum electrode was pre-treated by the method described in [1]. The duration of each OCP measurement experiment was 30 min.

First, an investigation of OCP in the blood serum of apparently healthy subjects was performed, showing that the time dependence of OCP can be described by an equation of the type:

$$y = a \ln x + b \qquad (1)$$

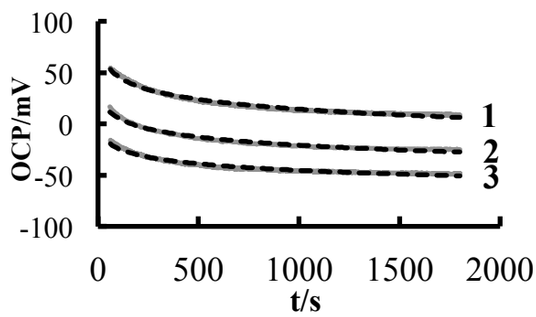

Fig. 1. Examples of trend lines of apparently healthy subjects.

As Fig. 1 shows, the model trend (dashed line) according to Eq. (1) corresponds to the experimental one (solid line) to at least 95%. Based on the analysis of time dependences of the platinum electrode OCP in the blood serum of apparently healthy subjects, curve parameters were computed: the coefficient in Eq. (1), $a = -10.496 \pm 2.619$, and the difference between OCP at 60 s and at 1800 s, $\Delta E_{(60\text{-}1800)} = 37.243 \pm 10.006$ mV.

When the influence of acute pathological states was studied in patients with kidney transplants, it was noted that the measured values of $\Delta E_{(60\text{-}1800)}$ for patients with favorable treatment outcomes were typically in the range characteristic for apparently healthy subjects (Fig.2, range marked by the two dashed lines).

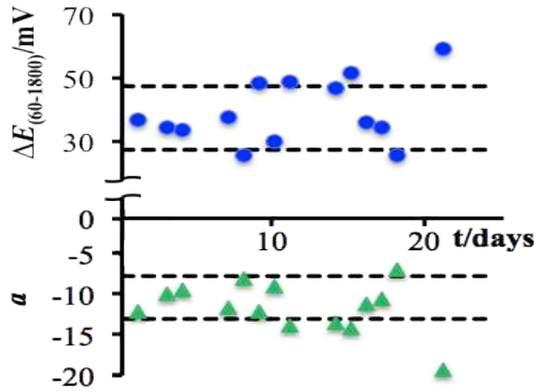

Fig. 2. Patient E. Values of a (computed) and $\Delta E_{(60\text{-}1800)}$.

When postoperative transplant dysfunction was observed, values of both the coefficient a and of $\Delta E_{(60\text{-}1800)}$ were outside the range characteristic of apparently healthy subjects. *I.e.*, for Patient S. (Fig. 3) with postsurgical pyelonephritis observed beginning in Day 8 and through Day 17, the values of a and $\Delta E_{(60\text{-}1800)}$ were outside the normal range, returning to it upon the patient's stabilization (Day 16).

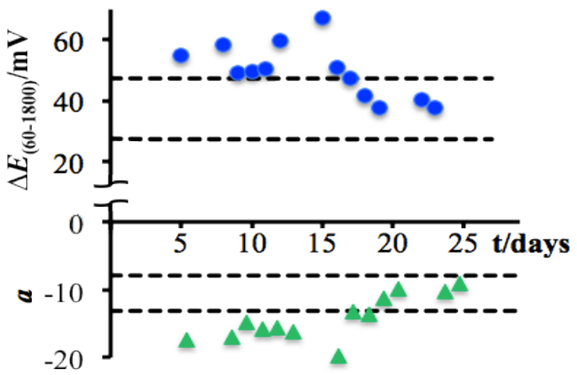

Fig. 3. Patient S. Values of a (computed) and $\Delta E_{(60\text{-}1800)}$.

Thus, the analysis of the time dependence of the platinum electrode OCP in blood serum provides additional information that can be used for evaluating the patient's condition. The use of both the "discrete" platinum electrode OCP value recorded after a set period of time and other additional characteristics of the OCP time dependence broaden the prospects of the method's application as a diagnostic tool of transplant dysfunction in the early postoperative stages of treatment.

1. M.Sh. Khubutiya, A.K. Evseev, V.A. Kolesnikov et al., *Russ. J. Electrochem.* **46**(5): 537–541 (2010).