The Summer Undergraduate Research Fellowship (SURF) Symposium
7 August 2014
Purdue University, West Lafayette, Indiana, USA

The Role of Metal Oxide Layers in the Sensitivity of Lactate Biosensors Subjected to Oxygen-Limited Conditions

Elizabeth Andreasen, Professor Lia Stanciu, and Aytekin Uzunoglu
Department of Materials Science and Engineering, Purdue University

ABSTRACT

Amperometric lactate biosensors are used to detect lactate concentration in blood and tissues, which is integral in identifying cyanide poisoning, septic shock, and athletic condition. The construction of lactate biosensors with high sensitivity, selectivity, and stability is imperative to diagnose and determine these medical conditions.

$$\text{Lactate} + O_2 \xrightarrow{LOx} \text{pyruvate} + H_2O_2$$
$$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$$

Lactate detection is currently limited to oxygen-rich environments due to the fact that oxygen is a limiting factor in the lactate reaction. To circumvent this problem, researchers have developed mediators or alternate, oxygen-free enzymes to improve sensitivity. In our study, ceria (CeO_2) with high oxygen storage capacity (OSC) was introduced to the enzyme layer to eliminate the effects of oxygen depletion. Fluctuation in oxygen concentration was combatted by use of ceria metal oxide nanopowders, which absorb and release oxygen under oxygen rich and lean conditions respectively. These nanopowders were deposited on the electrode surface in a polyelectrolyte solution. The lactate biosensors were then constructed using layer-by-layer assembly to take advantage of electrostatic interaction between the positively charged polyelectrolyte and negatively charged lactate oxidase (LOx). Polyethylenimine (PEI), a positively charged polymer, was used to immobilize the enzymes on the Pt surface via alternating electrostatic adsorption. It was observed that the introduction of ceria in the enzyme layer reduced oxygen dependency. The results showed that lactate biosensors with high selectivity, sensitivity, and wide detection limit were constructed.

KEYWORDS

Lactate biosensor, biosensor, oxygen storage capacity, ceria biosensor, amperometric biosensor

REFERENCES

Lei, Yang; Luo, Ning. A highly sensitive electrochemical biosensor based on zinc oxide nanotetrapods for L-lactic acid detection. Nanoscale, 2012, 4, 3438-3443.

Njagi, John; Ispas, Cristina; Andreescu, Silvana. Mixed ceria-based metal oxides biosensor for operation in oxygen restrictive environments. Analytical Chemistry, 2008,90,19,7266-7274.

Rodriguez, Marcela; Rivas, Gustavo. Assembly of glucose oxidase and different polyelectrodes by means of electrostatic layer-by-layer adsorption on thiolated gold surface. Electroanalysis, 2004,16,20,1717-1722.