Neural Networks for an Analysis of the Hemometabolites Biosensor Response

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ABSTRACT

In this work, the concentration dependent response of amperometric biosensor array for the biomarkers glucose, cholesterol and urease was explored, using artificial neural nets (ANN). The aim was to explore an array of amperometric biosensors for the discrimination of the biomarkers glucose, cholesterol and urea in blood. Seven out of eight platinum electrodes on the array were modified with four different enzymes; glucose oxidase, cholesterol, urease and peroxidase. The dynamic biosensor response curves from the eight sensors were used for ANN analysis. The ANN were applied to an analysis of the biosensor response to multi-biomarkers mixtures the ANN was able to detect the conditions with an accuracy up to 90%. The results obtained by using ANN to interpret the electrical signal of the developed biosensor arrays leads to the conclusion that: i) after training the ANN, the evaluation of recorded data are on-line, ii) microelectrode sites which are highly correlated to the information about the concentrations within the recorded signals was identified, iii) the recognition of blood biomarkers is improved by using the ANN.

Keywords: Artificial Neural Networks (ANN), Array Amperometric Biosensors, Biomarkers Glucose, Blood Biomarkers, Glucose Oxidase

INTRODUCTION

Today is well known that the ability to detect physiologically relevant molecules in the human body with high sensitivity and specificity is a powerful opportunity in early diagnosis and treatment of diseases. Early detection and diagnosis can be used to significantly reduction of the cost of patient care associated with advanced stages of many diseases. In 2007 the national cost of diabetes in the EUA exceeds US$174 billion (Diabetes.org, n.d.).

Studies have demonstrated that the high blood concentration levels of urea, cholesterol and glucose constitute high aggregation risk factors for development of cardiovascular or renal diseases (Lu et al., 2003; Shahid, Nawab, Shaikh, & Mahboob, 2012).
Currently, the biomarkers glucose, cholesterol and urea can be self-monitored by using enzyme biosensors. Self-monitoring of biomarkers can help both patients and their health care professionals better adjust to therapy and assess the responses to therapy. Benefits of self-monitoring of biomarkers include the fact that patients can immediately assess the impact of an action on blood glucose, urea or cholesterol levels and consequently undertake prompt interventions designed to counter the high blood glucose, urea or cholesterol concentrations.

An enzyme biosensor is commonly defined as an analytical device that uses enzymes as recognition system to target molecules or macromolecules. The enzyme biosensors can be coupled to a physiochemical transducer that converts this recognition into a detectable output signal (Shahid, Nawab, Shaikh, & Mahboob, 2012). Typically enzymes biosensors are comprised of three components: (1) the recognition element, which identifies the stimulus; (2) the transducer, which converts this stimulus to a useful output; and (3) the output system, which involves amplification and display of the output of the generated electric signal in an appropriate format (Figure 1).

Biosensors are classified according to the nature of the physical transducer. Amperometric biosensors measure changes of the current on a working electrode due to direct oxidation or reduction of the biomarkers at electrode surface due to the biochemical reaction. In this case, the potential at the electrode is held constant while the current flow is measured. Amperometric biosensors are reliable, relatively cheap and highly acceptable for clinical purposes (Wollenberger, Lisdat, & Scheller, 1997; Scheller, & Schubert, 1992).

In this work, the use of a sensor array with three amperometric sensors composed of three different enzymes was explored for determination of the biomarkers of cardiac and renal diseases cholesterol, urea and glucose (Figure 2).

### MATERIALS

#### The Chemistry in Biosensors

The main components of a biosensor are the enzymes. The enzymes are biocatalysts that have high selectivity rate. They are proteins with the specific function of speed up chemical reactions that occur under unfavorable thermodynamically conditions. They considerably accelerate the speed of chemical reactions in biological systems when compared to corresponding non-catalyzed reactions. This is achieved by lowering the activation energy required for a chemical reaction, resulting in increased speed.

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**Figure 1. Schematic diagram of a biosensor**

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