Modeling of the Physical Principle of the Processes that is Occurring in Bioselective Elements

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ABSTRACT

Design of biosensors refers to the field of interdisciplinary research, therefore, it is necessary to develop a unified systems approach that is invariant to the physical nature of the used phenomena and processes to create an automated system for conceptual design of such elements. It is appropriate to choose the fundamentals of non-equilibrium thermodynamics as the basis for the development of this approach. This article discusses the energy-information model of diffusion phenomena, as the processes of diffusion is the general type of the processes that is occurring in bioselective elements. A number of physical effects are described by this model. In this paper authors continue researches in the field of automation of design of biosensors which was presented at the 6th International Conference on Information, Intelligence, Systems and Applications. The new information technology of functional and structural design of biosensors is described. It is based on the energy-information model of chains, invariant to the physical nature of the processes occurring in technical devices. And it uses the device parametric structural diagrams allowing algorithmization of the search and selection of new technical solutions with estimation of their performance.

Keywords: Biosensor, Conceptual Design, Energy-Informational Model of Circuits (EIMC), Knowledge Database, Physical Effects

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1. INTRODUCTION

Today, biosensors have significant importance in hi-technologies and in the control of the various substances structure in industry, medicine, environmental protection. In 2013, the global market of biosensors is amounted to 11.39 billion dollars. By 2020, according to forecast of Markets & Markets (USA), this figure will increase to 22.68 billion with an average annual growth rate of 10% (Biosensors Market by Application, Product, Technology & Geography, January 2015).

Electrochemical biosensors have the largest market segment and optical biosensors have the fastest growing one. Modern micro and nano technologies offer additional benefits of possibilities in creation of instrumental in intelligent design of biosensors, in which the sensing element is combined with microelectronic circuits that control functional parameters and performing data processing, and providing communication with external equipment. Thus, the biosensors market is growing rapidly, requires all new construction and principles of operation of these devices with enhanced functionalities and improved performances. Increased market demands are forcing manufacturers intensively to expand the order of biosensors with new functionalities. However, even the leading firms in sensitive elements industry are using not more than 27-30% of the available physical phenomena that potentially could significantly expand the range of these devices (the data of the Endress & Hauser AG – a Swiss-based instrumentation and process automation company (Endress, 2004)). Thus, creation of the automated systems of conceptual design of biosensors would unify, reinforce and centralize the development process. Such systems allow reducing the time and workload for the creation of a new product, quick adaptation to the market changes, involving the commercial users into the design process, increasing significantly the knowledge-base for engineering education (Petrova et al., 2015).

2. DESCRIPTION OF THE SUBJECT AREA

2.1. Biosensors

In 1997, the International Union of Pure and Applied Chemistry (IUPAC) introduced the definition of the biosensor: biosensor is a device consisting of a transducer and an immobilized biological element (Interactive IUPAC, March 2015).

The biosensor is an analytical system, which contains biological material (enzymes, cells, antibodies, antigens, receptors, DNA fragments), which is in direct contact or embedded in the physical-chemical sensor (Thévenot et al., 2001). The generalized scheme of biosensor is shown in Figure 1.

In general Biosensors consist of the following two parts:

1. The biological sensing element (bio receptor). It is ensemble of biological molecules, with physical and chemical processes that convert environment properties into a measurable signal

Figure 1. The generalized scheme of the biosensor
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