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Electrochemical biosensors for fast detection of food contaminants – trends and perspective

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ABSTRACT

Biosensor technology represents an extremely wide field with a great impact to healthcare, environmental and food quality control. The aim of this review is limited to biosensors developed in the very last years specifically for monitoring food contaminants. The review covers the basic principles and types of electrochemical biosensors reported for food-specific applications. Innovation in materials science, nanotechnology and biomimetic design are reinforcing the biosensor field. This review highlights current and future trends in materials used for biosensing, miniaturization and development of portable devices in order to have on-site detection of the target analytes.

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1. Introduction

The impact of the biosensing technology is increasing in all major sectors such as pharmaceutical, healthcare, environment and food. Food safety is a global issue in the actual context of intensive development of the agriculture and the food industry. Nutrients monitoring and fast screening of contaminants represents some of the key issues in agrifood field for assessment of the food quality. The demand for developing simple, rapid, accurate, low-cost and portable analytical instruments is growing and biosensors fulfill these requirements. The current review is focused on the very recent advances in biosensing for the food quality control from the last 3 years and will not cover earlier published papers, unless it was considered necessary. Older publications are covered by many review articles have been published earlier [1–6]. We proposed an overview of the main types of the electrochemical biosensors with applications in food analysis and the most recent biosensing configurations with improved performance characteristics based on carbonaceous materials and nanomaterials, metal nanoparticles and molecularly imprinted polymers to understand and evaluate the state

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of the art of the subject. This review is structured on two parts. First one is addressing to the type of the biosensors taking into account the bio-recognition mechanism. Applications to food detection are discussed and examples of current publications are given. Advances in materials science, nanotechnology and biomimetic design are boosting the biosensing field. Therefore, the second part deals with some of the most used materials and nanomaterials used to improve the performances of the transducer or the whole biosensor or as immobilization matrix for bioreceptor. The most recent papers are discussed highlighting the advantages of the proposed approach. A special emphasis is given to a further step to be done in this field – from bench to market. For their implementation into the everyday life, the biosensors must come out from the laboratory. Miniaturization, automated analysis, low reagent consumption, portability, minimal demand on user time or skills and connectivity represent the demands for passing to commercially available biosensors.

2. Biosensors for food

Biosensors are analytical devices that integrate a biocomponent/bioreceptors (isolated enzymes, organelles, whole cells, tissue, immunosystems, nucleic acids, aptamers, etc.) with a suitable transducing system to detect chemical compounds. Common transducers are electrochemical, optical, mass based transducers (piezoelectric, surface acoustic), thermal transducers (thermistors and others. As a result of the specific interaction between the target molecule and the biocomponent an electrical signal is usually produced that can be measured and recorded. A wide range of analytes form inorganic compounds, small organic molecules to small proteins can be detected. Compared to the conventional methods used for food analysis, such as spectrometric or chromatographic methods, the biosensors have few incontestable advantages: selectivity that allow direct detection of the analyte without any sample pretreatment samples or minimal sample pretreatment, fast analysis with results in few minutes, low costs, perspectives for miniaturization and portability. Not the least, biosensors are very easy to be used and do not require highly trained personnel and therefore commercially available devices can be easily launched on the consumers market. Food quality control requires fast analysis and on the field available devices for testing different parameters. Biosensors come to meet these requirements and justify the increased interest of developing biosensors for food quality control. Basically, there are two types of compounds that are analyzed: compounds whose concentration presents interest for nutritional food quality and contaminants that are not supposed to be found in food products. Some other tests are performed to find information about the origin, counterfeiting or adulteration of the food products. Classification of the biosensors can be realized based on different criteria e.g. type of the bioreceptor or transducer, analytes or reactions monitored, detection or measurement mode [7]. Biochemical recognition mechanism was considered in this review to classify the biosensors and the main types of biosensors used for food analysis are presented in Fig. 1. Enzyme biosensors represent the main class of electrochemical biosensors used for food analysis. Two principles are used in this sense: substrate detection by its conversion in a reaction catalyzed by an enzyme with consumption or formation of an electroactive compound and detection of enzyme inhibitors. Substrate detection uses mainly enzymes from the oxido-reductases class (oxidases, peroxidases, dehydrogenases) and the main electroactive compound detected are hydrogen peroxide or reduced form of nicotinamide adenine dinucleotide (NADH). Determination of the inhibitors is performed by measuring the enzyme activity in the absence and in the presence of the inhibitor and correlation of the inhibition degree

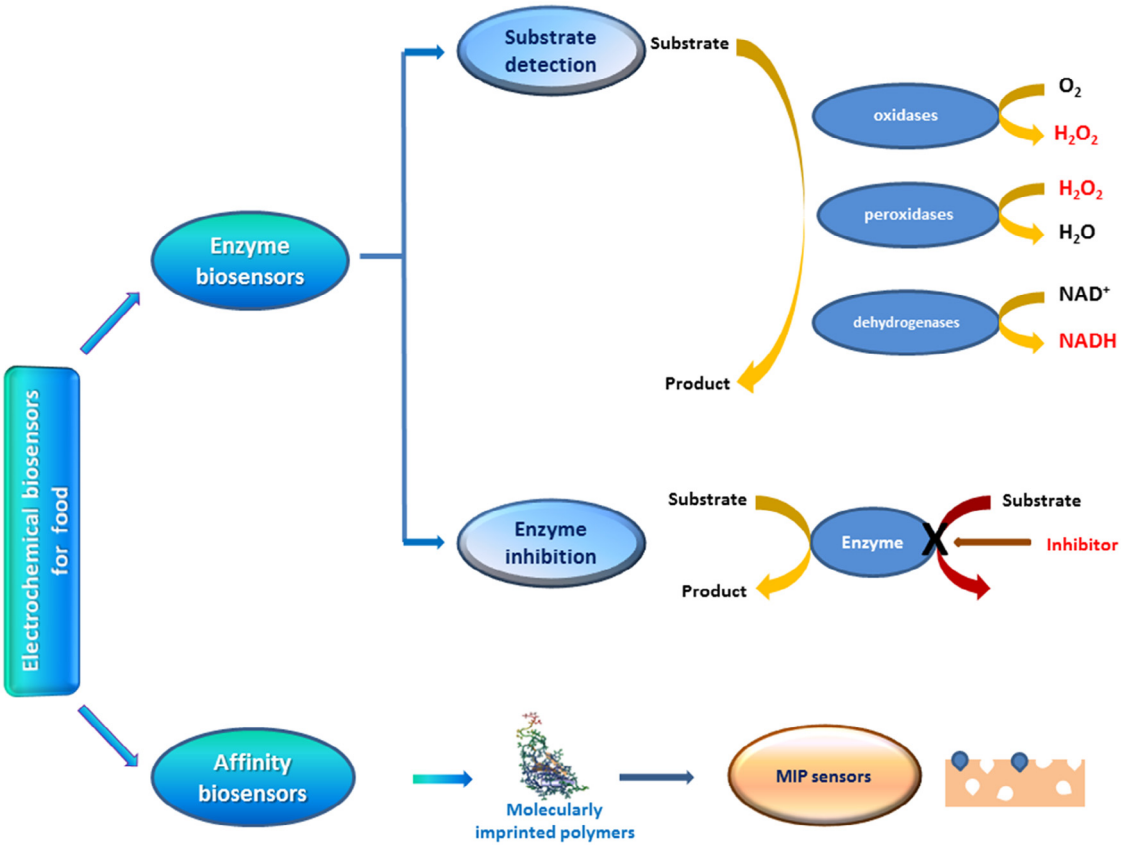

Fig. 1. Types of biosensors used in food analysis.