Novel biosensors for the rapid detection of toxicants in foods

The specific objective of this monograph is mainly to exploit progress in nanosciences to deploy nanotechnology in affordable, mass-produced sensors, and to integrate these into components and systems (including portable ones) for mass market applications in environmental and food monitoring. This monogram investigates the progress in the development of biosensors for the rapid detection of food toxicants for online applications. Sensing includes chemical and microbiological food toxicants, such as toxins, insecticides, pesticides, herbicides, microorganisms, bacteria, viruses and other microorganisms, phenolic compounds, allergens, genetically modified foods, hormones, dioxins, insecticides, pesticides, and herbicides, etc.

Biosensors are classified either to the physical transducer used or according to the biomolecule used to recognize the analyte of interest. The classification of biosensors according to the recognition element is the most common and important route for classification. This classification includes 5 categories of devices

Enzymatic Biosensors

Different enzymatic reactions commonly exploited for fabrication of biosensors are listed in Table 1:

Substrate	Enzyme	Species Detected	Detection
Choline	Choline oxidase	H_2O_2	Amperometry
Ethanol	Alcohol oxidase	H_2O_2	Amperometry
Formaldehyde	Formaldehyde dehydrogenase	NADH	Amperometry
Glucose	Glucose oxidase	H_2O_2, O_2	Amperometry
Glutamine	Glutamine oxidase	H_2O_2	Amperometry
Glycerol	Glycerol dehydrogenase	NADH, O_2	Amperometry
Hypoxanthine	Xanthine oxidase	H_2O_2	Amperometry
Lactate	Lactate oxidase	H_2O_2	Amperometry
Oligosaccharides	Glucoamylase, glucose oxidase	H_2O_2	Amperometry
Phenol	Polyphenol oxidase	Quinone	Amperometry
Hormones	Alkaline phosphatase (as label)	p-Nitrophenol	Amperometry
Aspartame	l-Aspartase	NH_3	Potentiometry
Fats	Lipase	Fatty acids	Potentiometry
Glucose	Glucose oxidase	Gluconic acid	Potentiometry
Urea	Urease	NH_4^+, CO_2	Potentiometry
Nitrite	Nitrite reductase	NH_4^+	Potentiometry
Penicillin	Penicillinase	H^+	Potentiometry

Sulfate	Sulfate oxidase	HS?	Potentiometry
Glucose	Glucose oxidase	Gluconic acid	ISFET
Penicillin	Penicillinase	Penicillic acid	ISFET
Triolein	Lipase	Fatty acids	ISFET
Ethanol	Alcohol dehydrogenase	NADH	Absorbance
Glucose	Glucose oxidase	O_2	Absorbance
Urea	Urease	Ammonia	Absorbance
Lactate	Lactate monooxygenase	NADH	Absorbance
Penicillin	Penicillinase	Penicillinic acid	Absorbance
Glutamate	Glutamate dehydrogenase	NADH	Absorbance
Pesticides	AchE	Acetic acid	Absorbance
Chlorophenols	Alkaline phosphatase	p-Nitrophenol	Absorbance
Ethanol	Alcohol dehydrogenase	NADH	Electrochemiluminescence

Table 1. Different enzymes commonly used in biosensors, their substrates, the species detected, and the detection mode used

Antibody-Based Biosensors

The majority of immunosensors use antibodies or antigen immobilized on the sensitive surface of the sensor. In the case of immobilized antigen, the recommendations for immobilization are not common and depend on its nature. The simplest way to immobilize the antibody is by physical adsorption. Another alternative is covalent coupling of antibodies to chemically activated surface of the sensor.

Ion Channel Switch- and Lipid Film-Based Biosensors

Studies are currently focused on the development and evaluation of methods for the incorporation of ion channels, enzymes, antibodies, or receptors in electrochemical, optical, or mass-sensitive detectors with lipid film as a recognition element or as an ion channel switch-based devices. An example of development of lipid films based sensors are glass fiber filter supported BLMs with incorporated artificial receptor that has been developed by our group for the rapid detection of carbofuran in fruits and vegetables.

Oligonucleotide and Nucleic Acid-Based Biosensors

Oligonucleotide and nucleic acid-based biosensors were used to measure toxic aromatic amines, oxidative damage, bioactivated benzo(a)pyrene, hydrazine, triazine-based herbicides, and fluorine derivatives, Recently, DNA damage biosensor has been applied to the detection of the antioxidant effect of apple and orange juices.

Tissue, Microorganisms, Organelles, and Cell-Based Biosensors

Living bacteria can be immobilized by physicochemical methods onto the measuring surface of the sensors. A few examples of these biosensors are:
1. A surface plasmon resonance (SPR) biosensor for the rapid identification of Campylobacter jejuni in broiler samples.
2. A novel SPR biosensor using lectin as bioreceptor.
3. A whole cell array biosensor for the efficient detection of neurotoxic organophosphate compounds.

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Publication

Novel Biosensors for the Rapid Detection of Toxicants in Foods.
Nikoleli GP, Nikolelis DP, Siontorou CG, Karapetis S, Varzakas T
Adv Food Nutr Res. 2018