Biosensors for environmental monitoring A global perspective

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Your Names

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Introduction

The increasing number of potentially harmful pollutants in the environment calls for fast and cost-effective analytical techniques to be used in extensive monitoring programs. The requirements, both in terms of time and costs, of most traditional analytical methods (e.g. chromatographic methods) often constitute an important impediment for their application on a regular basis. In this context, biosensors appear as suitable alternative or complementary analytical tools.

A biosensor is a self-contained integrated device, consisting of a biological recognition element in direct contact with a transduction element, which converts the biological recognition event into a usable output signal. Biosensors should thus be distinguished from bioassays where the transducer is not an integral part of the analytical system. Biosensors are usually classified into various basic groups according either to the method of signal transduction or to the biorecognition principle. Accordingly, biosensors can be categorized as electrochemical, optical, piezoelectric and thermal sensors on the basis of the transducing element, and as immunochemical, enzymatic, non-enzymatic receptor, whole-cell and DNA biosensors on the basis of the biorecognition principle. Reviews on these different groups of biosensors, including optical , electrochemical- thermal- microcantilevers- , immuno- , whole-cell- and DNA- based biosensors can be found in the literature.

Objective

1. elucidate the underlying principles and technologies;
2. identify the analytes that may be measured with biosensors;
3. provide details of available and forthcoming products;
4. review relevant, current research;
5. provide details of the activities of key research groups;
6. forecast future capabilities of biosensors, including perceived benefits and limitations, and timescales for development;
7. locate any biosensor activities underway by other UK organisations and Investigate scope for collaboration;
8. review the US EPA’s biosensor R&D programme;
9. investigate biosensor activities by other European environmental Agencles ;

10. investigate the implications of standardisation;
11. analyse the potential role of biosensors within the NRA and the Forthcoming Environment agency, including a consideration of the Operational and economic benefits that could be derived;
12. propose a strategy whereby the NRA/Environment Agency could move Forward, with an emphasis on collaborations, stimulating manufacturers To develop products that meet the NRA/Environment Agency requirements, And supporting academic or corporate R&D.

PRINCIPLE OF BIOSENSOR

Ecology tells us that each organism grows in specific set of conditions (niche) that can be defined in terms of food, temperature, moisture, pH, etc. One can thus use each organism as a biosensor for a set of conditions. After we learn to read these biosensors, pollution monitoring becomes a simple and quick job. We give below, a few guiding principles that one can use while learning this technique:

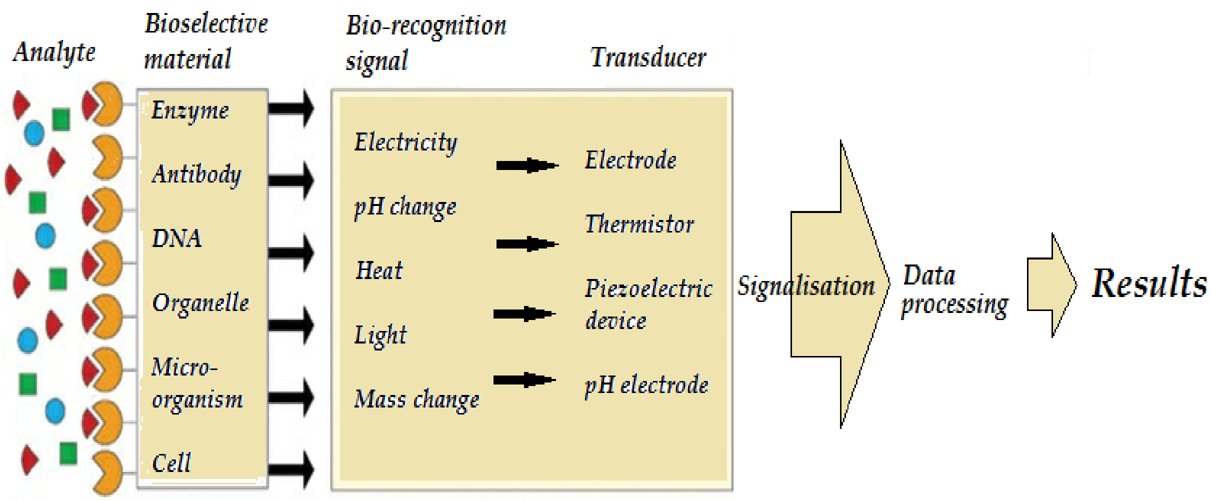
1. Pollution is a result of waste of resources, or in other words, waste is a misplaced resource.

2. Signs of pollution are visible and unpleasant, of varying degree, and only serve as warning signals. It is necessary to read this message and not fight with these signs of pollution (such as odor, pathogens, pests and several other unpleasant natural phenomena).

3.Biosensors inform us of the band or degree of pollution. This is quite enough to guide us towards an appropriate action

4. Appropriate action not only stops the signs of pollution, but display signs of prosperity. These Are clean air, clean water stream, flourishing vegetation, singing birds, etc. and absence of visible Nuisance-causing organisms (pests).

A biosensor is an analytical device composed of a biological sensing element (enzyme, receptor antibody or DNA) in intimate contact with a physical transducer (optical, mass or electrochemical) which together relate the concentration of an analyte to a measurable electrical signal. In theory, and verified to a certain extent in the literature, any biological sensing element may be paired with any physical transducer. The majority of reported biosensor research has been directed toward development of devices for clinical markets; however, driven by a need for better methods for environmental surveillance, research into this technology is also expanding to encompass environmental applications.



Types of Biosensors

Bisemors can be grouped according to their biological element or their transduction element Biological elements include errymes, antibodies, micro-organisms, biological usuar, and organelles. Antibody-based biosensors are also called immune sensors. When the binding of the sensing element and the analyte is the detected event, the instrument is described as a sensor. When the interaction between the biological clamauit and the analysis is accompanied or affinity followed by a chemical change in which the concentration of one of the substrates or products is measured the instrument is described as a metabolism sensor.

The method of transduction depends on the type of physicochemical change resulting from the sensing event. Often, an important ancillary part of a biosensor is a membrane that covers the biological sensing dement and has the main functions of selective permeation and diffusion control of analyte, protection against mechanical stresses, and support for the biological element On the basis of the transducing element, biosensors can be categorised as

I. Electrochemical :

Amperometric and potentiometric transducers are the most commonly used electrochemical transducers. In amperometric transducers, the potential between the two electrodes is set and the current produced by the oxidation or reduction of electro active species is measured and correlated to the concentration of the analyte of interest. Most electrodes are

S0044 is made of metals like platinum, gold, silver, and stainless steel, or carbon-based materials that are inert at the potentials at which the electrochemical reaction takes place.

II. Optical:

Fiber optic probes on the tip of which enzymes and dyes (often fluorescents)have been

co-immobilized are used. These probes consist of at least two fibers. One is connected to a light source of a given wavelength range that produces the excitation wave. The other, connected to a photodiode, detects the change in optical density at the appropriate wavelength.

III. Calorimetric:

Calorimetric trumdicers measure the heart of a biochemical reaction at the sensing element. These devices can be classified according to the way heat is transferred Isothermal calorimetry maintain the reaction cell at constant temperature using Joule heating or Peltier cooling and the amount of energy required is measured Heat conduction calorimeters measure the temperature difference between the reaction vessel and an isothermal heat sink surrounding it.

According to the bic recognition principle, biosensors are classified into:

IV. Enzymes:

Enzymes are proteins with high catalytic activity and selectivity towards substrates (see the article Enzyme Kinetics). They have been used for decades to assay the concentration of diverse analytes. Their commercial availability at high purity levels makes them very attractive for mass production of enzyme sensors. Their main limitations are that pH, ionic strength, chemical inhibitors, and temperature affect their activity.

V. Antibodies:

Antibodies are proteins that show outstanding selectivity. They are produced by b lymphocytes in response to antigenic structures, that is, substances foreign to the organem. Molecules larger than about 10 kDa can stimulate an immune response. Smaller molecules like vitamins or siemids can be antigenic (also called haptens) but they do not cause an immune response unless they are conjugated to larger ones like bovine serum albumin. Many antibodies are commercially available and commonly used in immunoassays

VI. Microbes:

The use micro-organism as biological elements in biosensors is based on the measurement of the metabelian, in many cases accompanied by the consumption of oxygen or carbon dioxide, and is, in most cases, measured electrochemically

Biosensors: Classifications, medical applications, and future prospective

Biosensors are devices that combine a biological material with a suitable platform for detection of pathogenic organisms, carcinogenic, mutagenic, and/or toxic chemicals or for reporting a biological effect. In recent years, an enormous number of different types of biosensors have been constructed and developed for several medical applications. The reason for that was primarily due to the numerous advantages and applications that can be offered by biosensors. This review article has been started with demonstrating the power of biosensor technologies versus analytical and conventional techniques. Subsequently, more emphasis has been added on the classification and the role of biosensors in several medical applications such as detection and monitoring of carcinogenic and mutagenic chemicals, reporting of endocrine disrupting compounds, and detection of pathogenic organisms. The most common reporter genes used in biosensors engineering and construction have also been summarized. Prospective strategies and recommendations for the future construction of biosensors have been highlighted.

Uses of biosensor

Nucleic acid biosensors for environmental pollution monitoring

Nucleic acid-based biosensors are finding increasing use for the detection of environmental pollution and toxicity. A nucleic acid-based biosensor employs as the sensing element an oligonucleotide, with a known sequence of bases, or a complex structure of DNA or RNA. Nucleic acid biosensors can be used to detect DNA/RNA fragments or either biological or chemical species. In the first application, DNA/RNA is the analyte and it is detected through the hybridization reaction (this kind of biosensor is also called a genosensor). In the second application, DNA/RNA plays the role of the receptor of specific biological and/or chemical species, such as target proteins, pollutants or drugs. Recent advances in the development and applications of nucleic acid-based biosensors for environmental application are reviewed in this article with special emphasis on functional nucleic acid elements (aptamers, DNAzymes, aptazymes) and lab-on-a-chip technology.

Genetically engineered microbial biosensors for in situ monitoring of environmental pollution

Microbial biosensors are compact, portable, cost effective, and simple to use, making them seem eminently suitable for the in situ monitoring of environmental pollution. One promising approach for such applications is the fusion of reporter genes with regulatory genes that are dose-dependently responsive to the target chemicals or physiological signals. Their biosensor capabilities, such as target range and sensitivity, could be improved by modification of regulatory genes. Recent uses of such genetically engineered microbial biosensors include the development of portable biosensor kits and high-throughput cell arrays on chips, optic fibers, or other platforms for on-site and on-line monitoring of environmental pollution.

Biosensors for environmental monitoring of endocrine disruptors

various types of physical-chemical signal transduction elements, biological mechanisms employed as sensing elements and techniques used for immobilisation of the bioreceptor molecules on the transducer surface. Two different classes of biosensors for EDCs are considered: biosensors that measure endocrine-disrupting effects, and biosensors that respond to the presence of a specific substance (or group of substances) based on the specific recognition of a biomolecule. Several examples of them are presented to illustrate the power of the biosensor technology for the environment.

CURRENT RESEARCH AND TRENDS:

ecae in many cases the traduction technology is well established, most of the research is focused on improving immobilization techniques of the biological element to increase sitivity, activity, and stability. While critical, the latter has received relatively little asta probably part because them is a tendency to design dipuble devices t useful in quality assurance laboratories Ist do not allow on-line implementation for process control Anther dynamic arm of ranh is uation of semers and flow systems Dement of these technologies is mainly driven by the mood for in visa applications for mac diagonals and may not find immolate use in the cultural and food distries. After alt 40 y of research in besemons, a wide gap between research and application is evid

The lack of validation, standardzie, and quantification of bioemers has resulted in a very slow taifa of technology. With fate computas and audymu this process should accelerate in the famine

CONCLUSION

Most biosensor systems have been tested only on distilled water or buffered solutions, but more biosensors that can be applied to real samples have appeared in recent years. In this context, biosensors for potential environmental applications continue to show advances in areas such genetic modification of enzymes and microorganisms, improvement of recognition element immobilization and sensor interfaces.

Thank you