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R E V I E W   A R T I C L E

A Review on Biosensors-Analytical Technique

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A B S T R A C T

Biosensor is a device that detects, records or transmits physiological data, especially data concerning the presence of chemical compounds (analytes) with the help of biological material such as microorganisms ,enzymes. This review discusses the components , biosensing and biotransducer elements, various types of biosensors such as enzyme based , tissue based , immuno sensors, optical sensors etc., and applications of biosensors in various fields such as medical, plant biology and clinical sector. Biosensors and their role in medical science including in the saccharification process to detect precise glucose concentrations, rapid detection of human papilloma virus, etc. are important aspects. Also the recent advances in biosensor technology like Nano biosensors.

Keywords: Biosensors, human papilloma virus, biosensing and biotransducer elements

A R T I C L E I N F O

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C O N T E N T S

1. Introduction

Biosensors are analytical devices that convert a biological response into an electrical signal. Quintessentially biosensors must be highly specific, independent of physical parameters such as pH and temperature and should be reusable[1].A biosensor is a device that - in some way - makes use of a biological detection system. Biosensing is the process of using biosensors to gather information about living systems. A chemically sensing device in which in which a biologically derived recognition is coupled to a transducer, to allow the quantitative development of some complex biochemical parameter. The biosensing components used in biosensors are highly capable of sensing the real time signals such as production of biomolecules like glucose, lactate, peroxides, and cytokines and release of proteins or antibodies in different inflammatory diseases and tumors. Because of the high demand in the market, blood glucose monitoring is the major application of biosensors so far. These biosensors can efficiently detect the target molecule in very low quantities and are considered to be powerful tool to detect disease at its initial stage and start the treatment early.

Components and Working Process of A Biosensor

- A Biosensor consists of three basic components:
- A detector to detect the biomolecule and generate stimulus,
- A transducer to convert the stimulus to output signal, and
- A signal processing system to process the output and present it in an appropriate form (shown in Figure).[2]

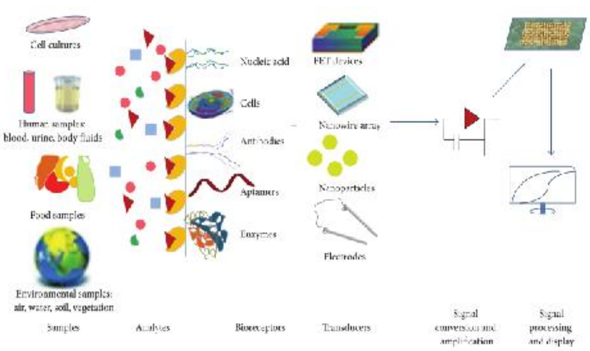

FIGURE 1: Schematic diagram showing the components of a biosensor. Reproduced after editing from Grieshaber [12].

Figure 1

The bioelement interacts with the analyte being tested and the biological response is converted into an electrical signal by the transducer.

2. Bio sensing Elements

Biosensing elements are a set of biological entity, those that are capable of carrying out specific group reactions or can bind with particular group of compounds, to yield a detectable signal that is read and transformed by the transducers. [3]

Enzymes:

Enzymes like glucose oxidize (GOx), horseradish peroxidase, and alkaline phosphatase have been widely used in many biosensor studies. Enzyme based biosensors have been extensively studied because of their medical applicability, commercial availability, and ease of enzyme isolation and purification from different sources.[4]

Microbes:

Microbes have been used as biosensing matrix in fabrication of biosensors. Their major advantages are that they are present ubiquitously, adapt to undesirable environment, and are capable of metabolizing new molecules with time.

Organelles:

Each organelle carries out specific function inside a cell and hence can be utilized in biosensing the specific analyte.

Cells and Tissues :

Cells have the ability to modify as per the surrounding environment for which they are subjected to be used as biosensing component. Adhesiveness to surface is another characteristic advantage that makes it a suitable candidate for immobilization on the matrix surface and attachment of receptors on cell membrane.[5]

Antibodies:

The antibody is a critical part of immune sensors. These immune sensors utilize the principle of highly selective antigen-antibody reaction. The antibodies are immobilized on the surface of matrix in an array format and linked to the transducers covalently through amide, esters, or thiol. The antibodies interact with the analyte, allowing modification at the functional groups attached to transducer surface for detection and quantification.

Nucleic Acids:

DNA is an appropriate candidate for bio sensing because of its specific ability of base pairing with complementary sequence. Nucleic acid biosensors (NABs) employ short synthetic single-stranded oligonucleotide probe that is immobilized on the transducer to detect the DNA/RNA in the sample.

3. Bio transducer Elements

Transducers are the elements which identify the stimulus released from the interaction of the analyte with the biosensing component and transform it into a detectable signal. Of all the developed biosensors, the commonly used are electrochemical, optical, and piezoelectrical.

Electrochemical Sensors:

These transducers measure the electrochemical changes that occur on the sensing surface of electrodes on interacting with the analyte (Figure 2).

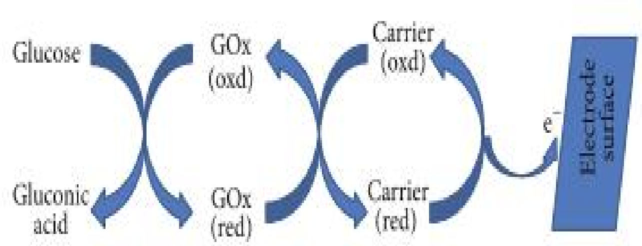

FIGURE 2: Diagrammatic representation of an enzyme modified electrochemical biosensor.

Figure 2

This technique is used commercially for detection of DNA/RNA, enzyme based assays like glucose and in field monitoring.

Optical Sensors:

The output transduced signal that is measured in these sensors is light based on its optical diffraction. Light in an optical device is directed towards the sensing surface through optical fibers or interferometer or dielectric waveguides and reflected back again (Figure 3). The reflected light is screened by a detector such as photodiode that calculates the physical changes occurring on the sensing surfaces.

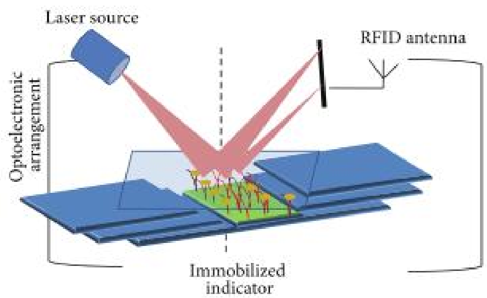

FIGURE 3: Architecture of an optical biosensor. Reproduced from Dey and Goswami [13].

Figure 3

Piezoelectric Sensors:

Piezoelectric sensors are also called mass sensors; the working principle of these biosensors is based on the interaction regarding the amount of analyte with the sensing element, usually a vibrating piezoelectric (PZ) quartz crystal. When an analyte of interest binds to the PZ sensing element, the resonant frequency of the PZ crystal changes. This creates an oscillating voltage that is spotted by the acoustic wave sensor.

4. Types of Biosensors

Organelle based sensors were made using membranes, chloroplasts, mitochondria, and microsomes but the detection time was longer, and the specificity was reduced.

Immunosensors were established on the fact that antibodies have high affinity towards their respective antigens, i.e. the antibodies specifically bind to pathogens or toxins, or interact with components of the host's immune system. The DNA biosensors were devised on the property that single strand nucleic acid molecule is able to recognize and bind to its complementary strand in a sample. The interaction is due to the formation of stable hydrogen bonds between the two nucleic acid strands. Optical biosensors consist of a light source, as well as numerous optical components to generate a light beam with specific characteristics and to beeline this light to a modulating agent, a modified sensing head along with a photo detector [6].

5. New generation Biosensors-Nano Sensors

Quantum Dots: Sensitivity and specificity of optical biosensors can be enhanced if coupled to quantum dots (QDs). QDs are nanometer-scale semiconductor crystals with unique quantum confinement effects. They have a broad excitation and narrow size-tunable emission band width, negligible photo bleaching, and ultra-stability [7]. They work on the principle of fluorescence transduction due to direct or indirect interaction of analyte with the QD surface.

Carbon Nanotubes:

Carbon nanotubes (CNTs) are cylindrical fabrication of rolled-up graphene sheet. CNTs based biosensors are promising candidates for biomedical application because of their attractive chemical and physical properties derived from graphene. Because of the strength of atomic bonds in carbon nanotubes, they can withstand very high temperature and act as excellent thermal and electrical conductor.

Lab-on-a-Chip:

It is a miniaturized device of utmost diagnostic importance integrates onto a single chip capable of analyzing one or several parameters including bimolecular, DNA, or RNA.

6. Applications Biosensors

Biosensors have been applied in many fields namely food industry, medical field, marine sector etc., and they provide better stability and sensitivity as compared with the traditional methods.[10]

In food processing, monitoring, food authenticity, quality and safety:

An arduous quandary in food processing industry is of quality and safety, maintenance of food products and processing. Traditional techniques performing chemical experiments and spectroscopy have shortcomings due to human fatigue, are expensive and time consuming. Alternatives for food authentication and monitoring with objective and consistent measurement of food products, in a cost effective manner, are desirable for the food industry.

In fermentation processes:

In fermentation industries, process safety and product quality are crucial. Thus effective monitoring of the fermentation process is imperative to develop, optimize and maintain biological reactors at maximum efficacy. Biosensors can be utilized to monitor the presence of products, biomass, enzyme, antibody or by- products of the process to indirectly measure the process conditions.

In medical field:

In the discipline of medical science, the applications of biosensors are growing rapidly. Glucose biosensors are widely used in clinical applications for diagnosis of diabetes mellitus, which requires precise control over blood.

Biosensors in plant biology:

Revolutionary new technologies in the areas of DNA sequencing and molecular imaging, have lead to advancements in plant science[11].However, this information can be easily successfully tapped using biosensors. To measure a dynamic process under physiological conditions, we need to device tactics to visualize the actual process, for instance, the conversion of one metabolite into another or triggering of signalling events. This visualization can be done by sensors which respond dynamically. [12]

7. Future Scope

Biosensors allow the researcher to sense levels of hormones, drugs, or toxins, continuously and noninvasively, using biophotonics or other physical principles. The scope in this regard could be of value in ageing research. Also detection of pollutants, heavy metal and pesticides through biosensors is one of the prime goals [13]. Applications of nanomaterials in biosensors provide opportunities for building up a new generation of biosensor technologies.The processing, characterization, interface problems, availability of high quality nanomaterials, tailoring of nanomaterials, and the mechanisms governing the behaviour of these nanoscale composites on the surface of electrodes are also great challenges for the presently existing techniques[14].Nevertheless, nanomaterial-based biosensors show great attractive prospects, which will be broadly applied in clinical diagnosis, food analysis, process control, and environmental monitoring in the near future.

8. Conclusion

The practical application of biosensors in medical world is still in its infancy. In order to meet the criterion of a precise diagnostic tool, these devices need further advancement in terms of simplicity, sensitivity, multiplex analysis of multiple biomarkers, and integration of different functions by the same chip[15].It necessitates continuous development and validation of biomarkers, development of ligands for those biomarkers, sample preparation methods, and multiplexing ability to analyze many cancer markers simultaneously.However, the cost needs to be adjusted in such a way that it can be affordable for all groups of people without compromising the quality control. It requires a concerted multidisciplinary approach for the development of clinically useful biosensor in the market at a reasonable price.

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