**Basic Concepts of Biosensor and Its Applications**

**Book series ID: IIPV3EBS16\_G3**

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**ABSTRACT**

Biosensors are the devices that capture the biological signal and convert it into a detectable electrical signal. It involves the combination of biological entities like DNA, RNA, and proteins/enzymes to the electrochemical transducers in order to detect and observe certain biological analytes like antibody-antigen interaction. It has five components. We give a general introduction to biosensors and biosensing technologies, including a brief overview, introducing key developments in the field and illustrating the breadth of biomolecular sensing strategies. The application of biosensors can be used for the detection of the broad spectrum of biological analytes and have shown greater responses and success in medical laboratories, food bioanalysis, microbial detection, environment etc.

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**Introduction**

By producing signals proportional to the concentration of an analyte in the reaction, a biosensor is an analytical tool that detects biological or chemical reactions. In applications like illness monitoring, drug discovery, and the detection of contaminants, disease-causing microbes, and markers that are signs of a disease in bodily fluids (blood, urine, saliva, sweat) [1], biosensors are used. In theory, biosensors are receptor-transducer based instruments that might be used to decipher the biophysical or biochemical characteristics of the medium. Intriguingly, the feature that distinguishes these sensors from others is the existence of a biological/organic recognition element, which makes it possible to identify certain biological molecules in the medium [2].

**Biosensor system and its** **components:**

Typically, a biosensor is made up of a bio-receptor (such as an enzyme, antibody, cell, nucleic acid, or aptamer), a transducer component (such as a semi-conducting substance or nanomaterial), and an electronic system that comprises a signal amplifier, processor, and display.[3] Electronics and transducers can work together, for instance in CMOS-based microsensor systems [4][5]. The recognition component, frequently referred to as a bioreceptor, interacts with the target analyte using biomolecules derived from living things or receptors based on biological systems. The biotransducer, which produces a detectable signal proportionate to the presence of the target analyte in the sample, measures this interaction. The main goal of a biosensor's design is to provide quick, convenient testing at the location of care or concern where the sample was obtained [6, 7, 8].

The following elements make up a typical biosensor.

Analyte: A material that has to be found and is of interest. One such "analyte" in a biosensor intended to detect glucose is glucose.

Bioreceptor: A bioreceptor is a molecule that uniquely recognises the analyte. Bioreceptors include things like enzymes, cells, aptamers, deoxyribonucleic acid (DNA), and antibodies. Bio-recognition is the process of signal production (in the form of light, heat, pH, charge or mass shift, etc.) in response to the contact of the bioreceptor with the analyte.

Transducer: An element known as a transducer transforms one form of energy into another. The transducer's function in a biosensor is to transform a bio-recognition event into a quantifiable signal. Signalization is the term used to describe this energy conversion process. The majority of transducers generate electrical or optical signals.

Electronic: The biosensor's electronics section processes the transduced signal and gets it ready for display. It is made up of intricate electrical circuitry that carries out signal conditioning tasks like signal amplification and conversion from analogue to digital form. The biosensor's display device then quantifies the signals that have been processed.

Display: The display consists of a user interpretation system that provides legible figures or curves for the user, like a computer's liquid crystal display or a direct printer. This component frequently consists of a hardware and software combination that produces user-friendly biosensor findings. Depending on the needs of the display, the output signal can be numerical, visual, tabular, or even an image [1].

**Components of biosensor**

 **Analyte Bioreceptor** **Transducer**  **Electronics** **Display**

**Characteristics of a biosensor:**

There are certain static and dynamic attributes that every biosensor possesses. The optimisation of these properties is reflected on the performance of the biosensor.

Selectivity

Selectivity is perhaps the most important feature of a biosensor. Selectivity is the ability of a bioreceptor to detect a specific analyte in a sample containing other admixtures and contaminants. The best example of selectivity is depicted by the interaction of an antigen with the antibody. Classically, antibodies act as bioreceptors and are immobilised on the surface of the transducer. A solution (usually a buffer containing salts) containing the antigen is then exposed to the transducer where antibodies interact only with the antigens. To construct a biosensor, selectivity is the main consideration when choosing bioreceptors.

Reproducibility

Reproducibility is the ability of the biosensor to generate identical responses for a duplicated experimental set-up. The reproducibility is characterised by the precision and accuracy of the transducer and electronics in a biosensor. Precision is the ability of the sensor to provide alike results every time a sample is measured and accuracy indicates the sensor's capacity to provide a mean value close to the true value when a sample is measured more than once. Reproducible signals provide high reliability and robustness to the inference made on the response of a biosensor.

Stability

Stability is the degree of susceptibility to ambient disturbances in and around the biosensing system. These disturbances can cause a drift in the output signals of a biosensor under measurement. This can cause an error in the meas-ured concentration and can affect the precision and accuracy of the biosensor. Stability is the most crucial feature in applications where a biosensor requires long incubation steps or continuous monitoring. The response of transducers and electronics can be temperature-sensitive, which may influence the stability of a biosensor. Therefore, appropriate tuning of electronics is required to ensure a stable response of the sensor. Another factor that can influence the stability is the affinity of the bioreceptor, which is the degree to which the analyte binds to the bioreceptor. Bioreceptors with high affinities encourage either strong electrostatic bonding or covalent linkage of the analyte that fortifies the stability of a biosensor. Another factor that affects the stability of a measurement is the degradation of the bioreceptor over a period of time.

Sensitivity

The minimum amount of analyte that can be detected by a biosensor defines its limit of detection (LOD) or sensitivity. In a number of medical and environmental monitoring applications, a biosensor is required to detect analyte concentration of as low as ng/ml or even fg/ml to confirm the presence of traces of analytes in a sample. For instance, a prostate-specific antigen (PSA) concentration of 4 ng/ml in blood is associated with prostate cancer for which doctors suggest biopsy tests. Hence, sensitivity is considered to be an important property of a biosensor.

Linearity

Linearity is the attribute that shows the accuracy of the measured response (for a set of measurements with different concentrations of analyte) to a straight line, mathematically represented as y=mc, where c is the concentration of the analyte, y is the output signal, and m is the sensitivity of the biosensor. Linearity of the biosensor can be associated with the resolution of the biosensor and range of analyte concentrations under test. The resolution of the biosensor is defined as the smallest change in the concentration of an analyte that is required to bring a change in the response of the biosensor. Depending on the application, a good resolution is required as most biosensor applications require not only analyte detection but also measurement of concentrations of analyte over a wide working range. Another term associated with linearity is linear range, which is defined as the range of analyte concentrations for which the biosensor response changes linearly with the concentration [1].

**Classification of biosensors**

Several approaches can be utilized for classification of biosensors on the basis of their biotransducer type [9,10].

a) Depending upon the used transduction principle, biosensors could be distributed into groups of electrochemical, mass dependent, optical, radiation sensitive and so on [11].

b) Enzyme, nucleic acid, proteins, saccharides, oligonucleotides, ligands etc. are the various sets of biosensors which could be acquired if bioelement is considered as the basis of categorization [12].

c) Following the type of detected analyte, classes of DNA, glucose, toxins, mycotoxins, drugs or enzymes-based biosensors could be achieved [13].

**Applications of biosensors**

Biosensors have a very wide range of applications that aim to improve the quality of life. This range covers their use for environmental monitoring, disease detection, food safety, defence, drug discovery and many more. One of the main applications of biosensors is the detection of biomolecules that are either indicators of a disease or targets of a drug.

For example, electrochemical biosensing techniques can be used as clinical tools to detect protein cancer biomarkers [14–16].

glucose monitoring in diabetes patients, other medical health related targets [17,18,19].

**Applications in tissue engineering**

In tissue engineering, biosensors plays immensely significant role in the applicability of the various applications, such as manufacturing “organ specific onchips” and maintaining the 3-D integrity and configuration of the cell cultures where the fate of tissues/cells is directly associated with the content of small biomolecules (adenosine, glucose, hydrogen peroxides etc.) [20].

**Applications in food industry**

identifying drug residues in food, including antibiotics and growth stimulants, with a focus on meat and honey. Salmonella, E. coli strain 0157:H7, Listeria monocytogenes, campylobacter, and E. coli are some of the bacteria that frequently cause food to degrade and pose health risks. These bacteria are frequent issues for the food industry because they decrease consumer demand for food if the food supplied by the company becomes contaminated with these biological agents that cause food to degrade [21]. In addition to bacteria, fungus are another prevalent source of food spoilage and serious health issues that, in many instances, can be fatal. Common fungal species that contaminate food include Botrytis sp., Aspergillus, Colletotrichum, and many others. Fungal toxins can also be identified utilising optical Surface Plasmon Resonance (SPR) biosensors because of their amazing selectivity, decreased prices, and simplicity and speed of monitoring through biosensors [22,23,24,25].

**Environmental applications of biosensors**

Applications in the environment include the detection of pesticides, the detection and identification of organophosphates, and the identification of pollutants in river water, such as heavy metal ions [26].

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