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REVIEW ON BIOSENSOR AND IT'S APPLICATION

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ABSTRACT

Using a transducer, biosensors connect a biological sensing element to a detector system. Electrochemical sensors for various analytes were the first to be effectively marketed and proposed scientifically. These days, there is a growing emphasis on the need to monitor and control a wide range of factors in fields like the food business, clinical diagnosis, hygiene, environmental protection, medication research, and forensics. As a result, having trustworthy analytical tools on hand that can conduct fast and precise analyses is essential. A biosensor is an apparatus that uses signals proportionate to the concentration of an analyte in a reaction to quantify biological or chemical responses. Applications for biosensors include disease monitoring, drug discovery, and the identification of contaminants and microorganisms that cause disease.It is made up of the following parts. Using a properly designed biosensor is one way to get around many of the drawbacks of the traditional methods. The primary rationale for biosensors' continuedTheir frequently unfeasibility in the stated domains is seldom utilized in realitysamples, but a biosensor designed for standards doesn't alwaysappropriate for actual samples.Biosensors are a newly described class of sensor that combine physical and chemical sensing techniques. Few IUPAC sensors are recognized for this kind of data. Plus, the majority of The medium's biophysical or biochemical properties. Additionally, the most.The biological/organic recognition element present in this type of sensor, which makes it possible to identify specific biological molecules in the medium, is an intriguing feature that distinguishes it from others. The creation of A new era of scientific advancement was ushered in by biosensors.

Introduction

These days, we are grateful for the advancements in science and technology that make life easier. We commonly rely on a variety of devices and appliances, which facilitate our interaction with the physical world. Examples include computers, copiers, cell phones, microwave ovens, refrigerators, air conditioning and television remotes, smoke detectors, infrared (IR) thermometers, and devices that turn on and off lamps and fans. Sensors are used in several of these applications to facilitate performance. A sensor is characterized as an apparatus or module that assists in identifying variations in physical quantities, including force, movement, heat, humidity, pressure, and electrical quantities, such as current, and subsequently transforms these variations into signals that can be identified and examined [1,2].Any apparatus that has the ability to change the form of energy is called a transducer. A measurement system's sensor is its central component. A perfect sensor should have the following qualities: high resolution, linearity, sensitivity, selectivity, calibration, drift, range, repeatability, repeatability, and reaction time [3,4].

The biological component, which includes things like tissue, microbes, organelles, cell receptors, enzymes, antibodies, and nucleic acids, among others. It measures chemical or biological reactions by producing a signal corresponding to an analyte'sconcentrationin the response. Biosensors are used in areas like illnessmonitoring, drug development, pollution detection, and disease-causingmicroorganisms and markers found in bodily fluids that serve as disease indicators such as sweat, blood, urine, and saliva1[5]

KEYWORD

Biosensor,Transducer,Bioreceptor,Analyte

COMPONENTS OF BIOSENSOR

There are three main sections to the biosensor.

Sensor: biological material that is sensitive to biological elements (such as tissue, microbes, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc.)

Transducer:The detector element, which can be optical, piezoelectric, electrochemical, or other physical in nature, is what changes the signal produced when the analyte interacts with the biological for the results' aesthetically pleasing presentation.

The associated electronics, which include a display unit4, a processor, and a signal conditioning circuit (amplifier), make up the third section.
Therefore, scientists' task is to create new ideas or enhance those that already exist in order to build biosensors that can be applied to actual samples and used in the commercial sector. This paper aims to present the progress made over the last five years concerning the fundamental functional principles of bio recognition elements and transducers in relation to particular applications of biosensors, such as environmental screening, food quality control, and clinical diagnosis. The use of non-materials in new trends is also discussed.

Analyte: An "analyte" within the context of a biosensor refers to the specific substance of interest that requires detection. To illustrate, in a biosensor designed for the purpose of detecting glucose, glucose itself serves as the analyte.

Bio-receptor: A "bioreceptor" refers to a molecule that possesses the capability to specifically recognize and bind to the analyte of interest. Examples of bioreceptors encompass a diverse range of biomolecules, including enzymes, cells, aptamers, deoxyribonucleic acid (DNA), and antibodies.The term "bio-recognition" pertains to the process in which a bioreceptor interacts with an analyte, resulting in the generation of a signal. This signal can take various forms, such as changes in light, heat, pH, charge, or mass shift, among others. Bio-recognition essentially signifies the molecular interaction that occurs between the bioreceptor and the analyte, leading to a detectable response.

Transducer: Within a biosensor system, a critical component known as a "transducer" serves the role of converting one form of energy into another. Specifically, in the context of biosensors, the transducer's primary function is to translate a bio-recognition event, wherein a bioreceptor interacts with an analyte, into a measurable and quantifiable signal. This process of converting energy is referred to as "signalization."Typically, the majority of transducers employed in biosensors produce either optical or electrical signals. These signals are often directly proportional to the extent of interaction that occurs between the analyte and the bio-receptors, allowing for precise and quantifiable measurement of the analyte's presence or concentration.

Electronics: In the biosensor system, this specific section is tasked with the crucial responsibility of processing the signal transduced by the transducer and preparing it for presentation. This section comprises intricate electrical circuitry designed to perform signal conditioning functions, including tasks such as signal amplification and the conversion of the signal from analog to digital form. Following this signal processing,the biosensor's display device is able to provide quantified and readable output based on the processed signals.

Display: The display component in a biosensor system is responsible for presenting user-friendly biosensor findings. It typically includes both hardware and software components, such as a computer's liquid crystal display or a direct printer. The output on the display can take various forms, including numeric data, visual representations, tabular data, or graphical illustrations, depending on the user's needs.[6]

PRINCIPLE

A biosensor is a tool for analysis that converts a biological reaction into an electrical signal. The term "biosensor" is commonly used to describe sensor devices that measure the concentration of chemicals and other biologically relevant properties without directly involving biological systems.To immobilize the necessary biological material, often a specific enzyme, traditional techniques are employed, including physical or membrane trapping, as well as non-covalent or covalent binding. This biological material is securely fixed in close proximity to the transducer. Changes linked to the product of the reaction can be converted by the transducer into electrical signals, which can be amplified and quantified. Generally, a biosensor utilizes a biological recognition component to detect the presence of the target species, or analyte. A biosensor system may encompass various components, including sampling, a biosensor, a data retrieval system, and a data processing system, to apply a biological model and transmit information to either a human or an automated controller. Considerations include the specificity, operational characteristics, storage requirements, and environmental stability of the biological material. Additionally, the biological material should generate a physical or chemical response that can be translated into a signal by a transducer.[6]

CHARACTERASTICS OF BIOSENSOR

A few static and dynamic requirements must be met in order to create a biosensor system that is both highly effective and capable. These specifications allow for the optimization of the biosensors' performance for commercial applications.

Selectivity: When choosing a bioreceptor for a biosensor, selectivity is an important factor to take into account. When admixture spices and undesirable contaminants are present in a sample, a bioreceptor can identify a specific target analyte molecule.

Sensitivity: The lowest quantity of analyte that can be accurately detected or identified in low concentrations (ng/mL or fg/mL) and in the fewest steps necessary to confirm the presence of analyte traces in the sample.

Linearity: The measured results' accuracy is enhanced by linearity. The substrate concentration detection increases with increasing linearity (straight line).

Response time: Ninety-five percent of the results require time to obtain.

Reproducibility: Precision (similar output when the sample is measured more than once) and accuracy (a sensor's ability to produce a mean value that is closer to the actual value when the sample is measured every time) are the two characteristics that define reproducibility. It is the biosensor's capacity to yield consistent findings after measuring the same sample multiple times.

Stability: One of the most important qualities in biosensor applications that call for constant monitoring is stability. The degree of susceptibility of the biosensing device to external and internal environmental perturbations is known as stability. The degree to which the analyte binds to the bioreceptor, or its affinity, and the bioreceptor's gradual degradation are the two variables that impact stability.[8]

Working

If you observe a device, you will notice that a biosensor are composed of three main parts :
● Recognition of analyte.
● Converting collected data to signal.
● Reading the signal.
In simple words, a biosensor consists of a biological component that helps the device recognize or communicate with the analyte. This communication produces a physical or chemical response which is further collected by a transducer. These changes can be magnetic, electrochemical, optical, thermal, etc. With this data, the transducer converts it into an electrical signal. These signals are then passed on to the electronic (amplifier, processor) to convert it into a readable form. Finally, after all these processes the output is displayed. [8][9][10]

TYPES OF BIOSENSOR

1. Electrochemical
a) Amperometric
b) Potentiometric
c) Conductometric
2. Thermometric
3. Optical
4. Piezoelectric
5. Microbial
6. Enzyme

Electrochemical Biosensor: Electrochemical biosensors commonly come equipped with electrode sets, and they are typically categorized into three main types based on the quantifiable characteristic they measure. These categories are as follows:

Amperometric Biosensors: These biosensors measure the current and are frequently employed to detect small compounds by initiating a redox (oxidation-reduction) reaction with an enzyme, such as peroxidase.

They are capable of detecting a wide array of chemicals within the human body, including glucose, cholesterol, uric acid, lactate, DNA, hemoglobin, and blood ketones, among others.

Potentiometric Biosensors: In potentiometric biosensors, the measurement is based on the potential difference or charge buildup.

Conductometric or Impedimetric Biosensors: These biosensors gauge changes in conductive or resistive qualities, and they are often considered as one category.
Each type of biosensor is selected based on the specific nature of the analyte being measured and the desired characteristics of the measurement process.

Amperometric Biosensor:
Amperometric detection is a widely utilized electrochemical detection technique in biosensors. It offers exceptional sensitivity for detecting biological samples containing electroactive species. Amperometric biosensors function by generating a current directly proportional to the concentration of the analyte under examination. The Clark Oxygen electrode is frequently employed in many amperometric biosensors.
An example of amperometric biosensors in action is seen in glucose meters. These devices use amperometric detection to measure glucose concentrations in blood samples with high sensitivity, providing a valuable tool for individuals managing diabetes to monitor their blood sugar levels.

Potentiometric Biosensor:
In this type of sensor, the parameter under monitoring is the oxidation or reduction potential of an electrochemical process. While it is less common than other biosensors, potentiometric sensors can employ various techniques. These sensors primarily measure the potential difference between working and reference electrodes at different analyte concentrations to determine the concentration of the analyte. Ion-selective electrodes are a crucial component of such sensors.
An example of a potentiometric sensor is a pH meter, which measures the pH of a solution by detecting changes in the potential difference between specific electrodes. Another example is the ion-selective Field Effect Transistor (ISFET), which is used for measuring ion concentrations in solutions.

Conductimetric Biosensor:
In this type of sensor, the parameter being measured is the electrical conductance or resistance of the solution. Electrochemical reactions that involve the generation of ions or electrons can modify the overall conductivity or resistivity of the solution. This alteration is appropriately scaled and quantified to determine the analyte concentration. However, it's worth noting that measurements of conductance often exhibit limited sensitivity.
An example of a biosensor utilizing this principle is a Urea Biosensor. It measures the concentration of urea in a solution by assessing changes in the solution's electrical conductance or resistance resulting from urea-related electrochemical reactions.

Thermal Biosensor:
Thermal transduction in biosensors relies on calorimetric principles, where temperature changes are employed for measurement. Thermistors, which are temperature-dependent resistors, are commonly utilized as the detection components in thermal biosensors. The initial thermal biosensor was labeled as an "enzyme thermistor," similar to how the first amperometric biosensor was termed an "enzyme electrode." This specific type of biosensor leverages one fundamental aspect of biological reactions—the absorption or generation of heat, which subsequently alters the temperature of the reaction medium. Immobilized enzyme molecules and temperature sensors are combined to construct these biosensors.
An example of a biosensor that operates on thermal transduction is an Isothermal Calorimeter. It utilizes temperature changes as a means of measuring various biochemical processes and reactions, offering valuable insights into the energetics of biological reactions.[11]

Optical Biosensor:
Optical biosensors are devices that rely on optical measurements. They often incorporate fiber optics, and the term "optode" is a combination of "optical" and "electrode." Similar to other biosensors, these devices utilize antibodies and enzymes as transducing elements. Optical fibers play a vital role in optical biosensors, enabling the detection of sensor components through various properties of light, including absorption, scattering, and fluorescence.

An illustrative example of an optical biosensor is a Fluorescence Immunoanalyzer. This type of biosensor utilizes fluorescence measurements to detect and quantify specific molecules, typically involving the use of antibodies or other recognition elements to bind with target analytes and produce fluorescent signals for analysis.

Piezoelectric Biosensor:
Piezoelectric biosensors employ the piezoelectric effect, which is the conversion of mechanical energy into electrical energy using crystals. These biosensors are designed to convert variations in pressure, acceleration, temperature, strain, or force into an electrical charge, allowing for precise measurement of these parameters. The term "piezo-" originates from the Greek word "piezein," meaning "to press" or "to squeeze."
An example of a biosensor that utilizes piezoelectric technology is an Accelerometer. Accelerometers measure changes in acceleration and can be found in various applications, including motion detection in electronic devices and monitoring physical activity in wearable technology.

Microbial Biosensor:
Microbial biosensors are formed by combining microorganisms with a transducer. These biosensors facilitate rapid, accurate, and sensitive detection of specific target analytes across a range of applications, including medicine, environmental monitoring, defense, food processing, and safety. In the earlier versions of microbial biosensors, the respiratory and metabolic activities of microorganisms were harnessed to detect substances that either served as substrates for these processes or acted as inhibitors. These microbial biosensors leverage the unique capabilities of microorganisms to respond to specific substances, making them valuable tools for analytical purposes in various fields.
Enzyme Biosensor: The cornerstone of enzyme biosensors lies in biological recognition. Enzymes used in these biosensors must possess the capability to catalyze specific biological reactions and maintain stability under the standard operational conditions of the biosensor. An enzyme biosensor comprises a sensitive system that integrates a membrane-immobilized enzyme with an electrode transducer. This combination of the enzyme and electrode is essential for the proper functioning of the biosensor, allowing for the detection and quantification of specific analytes in various applications.[11]

APPLICATIONS OF BIOSENSOR

Biosensors in Food Industry
Biosensors are employed for the detection of pathogens in food, including the identification of Escherichia coli (E. coli). Vegetables that contain E. coli can serve as biomarkers for fecal contamination in food products. To determine E. coli concentrations, potentiometric alternating biosensing devices are used. These devices detect changes in pH caused by the presence of ammonia, which is produced as a result of the interaction between urease and the E. coli antibody conjugate. This approach allows for the sensitive and specific detection of E. coli in food, aiding in food safety and quality control measures.

WEARABLE BIOSENSOR (WBS)
Digital devices designed to be worn on the body are referred to as Wearable Biosensors (WBS). Wearable items encompass a wide range of devices such as smart bands, smartwatches, slim bandages, rings, and similar items. These biosensors play a crucial role in monitoring the vital signs of various individuals, including patients, athletes, premature infants, children, psychiatric patients, individuals requiring long-term care, and those residing in remote or inaccessible areas, far from healthcare facilities. Their effectiveness extends to disease control, prevention, and treatment, significantly enhancing healthcare outcomes.

●Smart watches
Among the crucial wearable technologies, the smartwatch stands out. It frequently monitors specific human physiological signals and biomechanics, serving as a fitness tracking device that empowers users to record their daily activities. This includes automatically recording exercise durations, monitoring heart rate, tallying step counts, and calculating calories expended. Smartwatches collect data, which is subsequently transmitted to a server or smartphone for analysis. They achieve this through the utilization of internal and external sensors integrated with a lithium-ion battery.

●Smart socks
These devices are equipped with sensors capable of monitoring various aspects of movement, including walking and the way in which the feet interact with the ground in various scenarios such as walking, running, or sitting positions.

●Ring sensor
This is a pulse oximetry sensor designed for measuring oxygen saturation and heart rate. The ring-shaped device is intended for continuous and extended wear. It features an RGB LED and includes an integrated infrared LED and photodiode within the ring. The entire operation is managed by a single processor.

●Eye glasses
These glasses serve as wearable head-mounted computers with an integrated display. They are equipped to simultaneously monitor sweat lactate and potassium levels using a gel-membrane. In addition, the glasses are fitted with a nosepiece for tracking vital signs and optical sensors for detecting injuries. This advanced system includes monitoring capabilities, data processing components, and wound detection. The sensors can be easily positioned in optimal locations for all users and can be cleaned without causing damage. This technology assists in monitoring temperature, respiration rate, and heart rate. The garment consists of two layers: the first is crafted from regular fabric, while the second incorporates a membrane to prevent excessive sweating, particularly in infants.[12]

Agricultural Industry
Enzyme biosensors have been effectively utilized to detect pesticide residues, particularly organophosphates and carbamates, through the inhibition of cholinesterases. Research has also focused on developing methods for quantifying ammonia and methane using selective and highly sensitive microbial sensors.
In the realm of wastewater quality management, the only commercially available biosensors currently in use are Biological Oxygen Demand (BOD) analyzers. These analyzers rely on microorganisms, such as the bacterium Rhodococcuserythropolis, which are immobilized within materials like collagen or polyacrylamide. BOD analyzers play a critical role in assessing the quality of wastewater, providing valuable data for wastewater treatment processes and environmental compliance.[13-14]

CONCLUSION

Biosensors are an impressive technological tool that provide quick, affordable detection with exceptional sensitivity and specificity. Their main influence is on healthcare and disease detection. The food, agricultural, and environmental sectors have all benefited from the effective use of biosensors in medical diagnostics. Extensive research is being conducted by diagnostic centers and research and development firms to develop biosensor technologies that are inexpensive, sensitive, and easy to use.
The development of the "enzyme electrode" for blood glucose monitoring signaled the start of biosensor research and development fifty years ago. Since then, the primary motivation behind biosensor research has been clinical applications. Despite their potential for rapid and simple analyte detection, biosensors, in contrast to well-established immunoassay techniques, have not yet become commonplace in clinical practice.
Ongoing research and development are focused on creating advanced biosensors capable of data sharing through telecommunications networks and integration with smartphone and tablet technologies. The ultimate goal is to develop intelligent systems capable of identifying the molecular origins of various events. This advancement could lead to the use of synthetic molecules in sensing systems, eliminating the need for unstable natural ligands. Another potential avenue for this technology's evolution is the development of hybrid devices that rely on nanotechnology for production.

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