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Biosensors a Review

1. Pallavi Dadarao Rathod, *Student, Vardhaman college of pharmacy*
2. Nitin B. Kohale, *principal, vardhaman college of pharmacy*
3. Suraj B. Rathod, *Assistant professor, Vardhaman college of pharmacy*
4. KusumR. Rajbhar, *Assistant professor, Vardhaman college of pharmacy*

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Abstract :
As the potential threat of bioterrorism increases, there is a strong need for tools that can quickly, reliably, and accurately detect atmospheric pollutants. Biosensors, among other everyday applications, essentially serve as inexpensive and highly efficient devices for this purpose. A biosensor is a sensing device that consists of a specific biological element and transducer combination. A "specific biological entity" recognizes a specific analyte, and changes in biomolecules are typically converted into electrical signals by transducers (which are calibrated to a specific scale). Biosensors are widely used and have become the most popular choice for manufacturers. This article explains what biosensors are, how they work, what they are used for, and what types of biosensors are used.

Keywords: Biosensors, Working, Types of Biosensors, Application of Biosensor

I. Introduction:

The history of biosensors began in 1962 with the development of enzyme electrodes by scientist Leland C. Clark. Since then, research communities from various fields such as VLSI, physics, chemistry and materials science have come together to develop more sophisticated, reliable and sophisticated biosensing devices for medical, agricultural and biotechnology applications. Has been developed.

1. What are Biosensors?

There are different definitions depending on the field of application. But simply put, "A biosensor is a device used to measure the concentration of an analyte (the analyte could be any biological element, depending on the application. Examples of analyte in glucometers are blood and sugar.) These devices can convert biological responses (analyte responses) into electronic signals"[1]. Biosensors use unique biological recognition elements that change properties when bound to specific elements. This helps you monitor your environment and physical connections. Biosensors are simple, fast, inexpensive, sensitive, and highly selective. Advances in surface chemistry have provided a variety of new avenues for the development of detector detection systems. Combining intelligence fromDifferent fields will help accelerate the development of biosensors and transform the biological field [3][5]. A biosensor's performance is affected by optimizing its static and dynamic properties.

2. **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.
- Simply put, biosensors consist of biological components that help devices recognize or transmit analyte. This communication causes a physical or chemical reaction that is further sensed by the transducer. These changes can be magnetic, electrochemical, optical, thermal, etc. A converter uses this data to convert it intoAn electrical signal. These signals are passed to electronics (amplifiers, processors) to convert them into a readable form. Finally, after all these processes you will see the output. [2][5][6]

3. Types of Biosensors

This section describes some common types of biosensors.

3.1. Resonant biosensors:

In this type of biosensor, an acoustic transducer is attached to an antibody (biological element). When an analyte molecule (or antigen) binds to the membrane, the mass of the membrane changes. The resulting change in mass changes the resonant frequency of the transducer. This frequency change is then measured.

3.2. Biosensors with optical detection:

The transmitted output signal that is measured is light for this type of biosensor. Biosensors can be made based on optical diffraction or electrochemiluminescence. In optical diffraction-based devices, proteins are coated onto silicon wafers via covalent bonds. The wafer is exposed to UV light through a photomask and the antibodies are deactivated in the exposed areas. When the sliced wafer chip is incubated in the specimen, antigen-antibody bonds form in the active region,Forming a diffraction grating. This diffraction grating produces a diffraction signal when illuminated by a light source such as a laser. The resulting signal can be measured or further amplified before measurement to improve sensitivity.

3.3. Thermal biosensors:

This type of biosensor takes advantage of one of the fundamental properties of biological reactions: the absorption or generation of heat. This changes the temperature of the medium in which the reaction takes place. They are constructed by combining immobilized enzyme molecules and temperature sensors. When the analyte contacts the enzyme, the thermal response of the enzyme is measured and calibrated against the analyte concentration. The total heat produced or absorbed is proportional to the molar enthalpy and the total number of molecules in the reaction. Temperature is usually measured via a thermistor, and such devices are known as enzymatic thermistors. Due to their high sensitivity to thermal changes, thermistors are ideal for such applications. Unlike other transducers, thermal biosensors do not require frequent recalibration and are unaffected by sample optical and electrochemical properties. Common applications for this type of biosensor include detection of pesticides and pathogens.

3.4. Ion-sensitive biosensors:

These are semiconductor field effect transistors with ion-sensitive surfaces. When ions and semiconductors interact, the surface potential changes. Then we can measure the change in this potential. An ion sensing field effect transistor can be constructed by covering the sensor electrodes with a polymer layer. This polymer layer is selectively permeable to four analyte ions. The ions diffuse through the polymer layer and change the surface potential of the field effect transistors. This type of biosensor he also called enzyme field effect Transistor is mainly used for pH detection.

3.5. Electrochemical biosensors:

Electrochemical biosensors are mainly used to detect hybridized DNA, DNA-binding drugs, glucose concentration, etc. The principle underlying this class of biosensors is that many chemical reactions produce or consume ions or electrons, which cause some change in the electrical properties of a solution, which can be detected and used as a measurement parameter. That’s it. Electrochemical biosensors can be classified based on the electrical parameter measured as follows:(1)Electrical conductivity, (2) amperometric, and (3) potential difference. A comparison of these three types of electrochemical biosensors is

3.5.1. Electrical conductivity:

The measurement parameter is the conductivity/resistance of the solution. Electrochemical reactions produce ions or electrons that change the total conductivity or resistivity of a solution. This change is measured and calibrated to the appropriate scale. The sensitivity of conductivity measurement is relatively low. The electric field is generated with a sinusoidal voltage (AC) to minimize unwanted effects such as Faraday processes, double layer charging and concentration polarization.

3.5.2. Amperometric:

This highly sensitive biosensor can detect electroactive species present in biological test samples. Biological test samples may not be electroactive in nature, so enzymes must catalyze the production of radioactive species. In this case the measurement parameter is current.

3.5.3. Potential difference:

In this type of sensor the measured parameter is the oxidation or reduction potential of the electrochemical reaction. The principle of operation is that when a ramp voltage is applied to electrodes in solution, an electrochemical reactionCauses current to flow. The voltages at which these reactions occur are indicative of specific reactions and species.

3.6. Immunobiosensors:

Immunobiosensors work by combining immunological discrimination with measurement by amperometric or potentiometric biosensors. The relative concentration of labeled and unlabeled antigen affects the activity of enzymes associated with immunosensors. Enzyme activity can be used to determine the concentration of activated antigen

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4. Glucose Biosensor :

The most commercially successful biosensors are amperometric glucose biosensors. These biosensors It comes on the market in many shapes and forms, such as glucose pens, glucose. Advertising, etc. The first historical experiment that gave rise to the glucose biosensor was Leland C. Clarke. He used platinum (Pt) electrodes to detect oxygen. Enzyme glucose oxidase was placed very close to the platinum surface by being physically trapped against it. Electrodes with dialysis membrane strips. Changes the enzyme activity. Five Ambient oxygen concentration. Fig.2 shows the reaction catalyzed by glucose oxidase. Glucose reacts Glucose oxidase forms gluconate by forming two electrons and two protons. Reduce god Reduced glucose oxidase, ambient oxygen, electrons, and protons (generated above) react Forms hydrogen peroxide and oxidized glucose oxidase (original form). This god can react to you again more glucose. The higher the glucose level, the more oxygen is used. While lower Glucose content leads to more hydrogen peroxide. Therefore, the consumption of oxygen or Hydrogen peroxide production can be detected using platinum electrodes, which can help As a measure of glucose concentration. Disposable amperometric biosensors for detecting glucose are also available. Typical The configuration is a button-shaped biosensor consisting of the following layers: metal substrate, graphite layer, insulating layer, mediator-modified membrane, immobilized enzyme membrane glucose oxidase, Cellulose acetate membrane. This biosensor uses graphite electrodes instead of platinum Electrodes (originally used by Clarke). Placing an insulating layer on the graphite electrode Certain impurities (ascorbic acid, uric acid) can be removed and passed at the same time hydrogen peroxide and oxygen. Mediator Modified Membrane helps maintain glucose oxidase. A membrane attached to a graphite electrode whenan electrochemical reaction takes place in Specific applicability. A cellulose acetate skin layer is also placed on top of the glucose oxidase membrane Provides a barrier against contaminants. Biosensor current reading (current versus glucose concentration) indicates that the relationship is linear up to a certain glucose concentration. In other words, the current increases proportionally with glucose concentration, so this may be theCase Used for detection. Current and future applications of glucose biosensors are important. Used for self-monitoring of capillary blood glucose in diabetic patients. These types of monitoring devices include One of the largest markets for biosensors today, its presence has improved dramatically Quality of life for people with diabetes.

5. Biosensors to monitor cell morphology :

Another type of biosensor can be used to monitor cell morphology in a tissue culture environment. Or The sensor principle used is known as Electric Cell-Substrate Impedance Sensing. During this process, A small gold electrode isImmersed in tissue culture medium. When cells stick together and spread The electrodes change the impedance measured between them. This changing impedance is Used to understand cell behavior in culture. Cell attachment and diffusion behavior are important factors for these types of biosensors. Cancer cells normally grow in culture and are free to proliferate (mitosis) without attachment on any substrate/surface. Normal cells, on the other hand, must first adhere to the surface 6 growing up. After pinning, the cell shape flattens and no longer remains spherical. Figure 3.We show the behavior of this cell in tissue culture medium. The measurement principle is as follows. Cells grow on gold electrodes. Or Electrodes are immersed in tissue culture medium, which acts as an electrolyte. Voltage I passed it through a resistor and measured the magnitude and phase of the voltage with a lock-in amplifier. Since the current is constant, we can assume that the measured magnitude and phase are proportional to: Impedance (resistance and capacitance). It is less time consuming than traditional methods, Cell morphology measurements can be automated and quantified, and patterns of variation are Used as cell signature.

6. APPLICATIONS :

6.1. Environmental Science:

Our environment has absorbed various pollutants due to recent industrialization and modernization. These include heavy metals, herbicides, complex hydrocarbons, and other substances. However, many biosensors have been developed solely to address environmental concerns.[11]

6.2. Heavy metal detection:

As you know, the environment contains both important and harmful metals. Accumulation of heavy metals that are toxic to humans can cause many major health problems, including damage to the liver, kidneys, brain system and even reproductive system. It does not react to all heavy metals in [3]. Therefore, it is suitable only for the development of special heavy metals.However, if you want to build biosensors for toxicity and analysis, you can use different enzymes. This is where enzyme-based products come in. Enzyme-based biosensors can be used in this situation.

6.3. Pesticide detection:

We all know the drawbacks of using pesticides as they can be harmful to human health. When farmers are exposed to pesticides without proper protective equipment, they can develop serious long-term health problems such as cancer. It can also create an imbalance in our healthy environment. . Pesticide detection is performed using amperometric biosensors, a type of electrochemical biosensor. [13][15]

6.4. Medical Science:

- Cancer detection: Cancer is a leading cause of death worldwide and its incidence is increasing. Each year, 12.7 million people are diagnosed with cancer and 7.6 million die from it. However, data suggest that 30-40% of these deaths could be avoided and one-third could be cured if diagnosed and treated early [6]. With early detection of breast cancer, the survival rate is 98% [10]. A biosensor based on the concept of surface plasmon resonance (SPR) is a useful device for early detection of cancer. It is well known that biosensors can convert biological responses into electrical signals [14]. For cancer detection, tumor cells serve as the specimen. Biosensors can identify cancer cells by detecting the amount of specific proteinsReleased or expressed by tumor cells. By collecting data from tumor cells, it is possible to determine whether the tumor cells are malignant or non-cancerous [15][16][11][12][13].
- Wearable Biosensors: In the past, patients had to ask their doctors about blood sugar levels, weight for heart failure, and breathing for COPD and asthma. But today's patients have access to wearable sensors that they can use at home to accurately tell them all about their body. Wireless technology can monitor patients during dangerous surgeries and even in busy emergency rooms, with wearable biosensors playing a big role.[17]

6.5. Technology:

- Food quality:

Foods can suffer from poor microbial growth as a result of digestion, and tracking such deviations over time can provide an overall estimate of food quality [1][Four]. Biosensors enable intelligent and responsive packaging for monitoring food freshness, which plays an important role in food science. When the biosensor is near food, readings can be taken from the received signal to determine the quantity and purity of the food sample. The results are displayed on the LCD and you can evaluate whether the food is of good or poor quality. Biosensors can be used in a variety of settings such as hotels, private homes and even small businesses. ThisTechnology manages food chain monitoring without human intervention. (Buzzers connected to sensors have been used in some small experiments to help visually impaired people determine food quality).

- Detection of allergen:

Food allergies are becoming a serious public health and food safety problem worldwide. People who are allergic to certain foods have negative reactions. It's hard to heal, so it's safer to avoid it. As the risk of hidden food allergies increases, the demand for fast, accurate, and accurate food allergen tracking technology is increasing worldwide. Microfluidic biosensors can help detect these allergens present in food.[15] Furthermore, according to [3], Escherichia coli is the most dangerous food-borne pathogen. It causes extreme symptoms such as bloody diarrhea and hemorrhagic colitis. It is so deadly that it is one of the leading causes of food poisoning deaths worldwide. Traditional methods of detecting this pathogen are very time consuming and inefficient. E. coli can turn into an incurable disease, so timely diagnosis is very important. Therefore, biosensors such as optical and electrochemical biosensors have been developed to diagnose ecoli. In 2017, Zhang et al. developed a biosensor, a multi-channel SPR-based biosensor capable of detecting very low abundance pathogens [3], which proved to be a lifesaver.

6.6. Market Analysis:

From 2021 to 2030, the biosensor market is expected to grow from US$25.5 billion in 2021 to US$36.7 billion at a CAGR (Compound Annual Growth Rate) of about 8% [20]. Development of nanotechnology-based biosensors, significant technological advances in recent years, growing need for biosensors to monitor blood glucose levels in diabetics, increasing demand for portable and easy-to-use devices during the COVID-19 pandemic , and increasing medical therapy in social programs are some of the key drivers of the biosensing business (nanotechnology-based biosensors are made from nanoparticles less than 100 nanometers in diameter [18]. These bio sensors are important for understanding how biosensing systems work). According to WHO, about 1.7 billion people were obese in 2016, of whom about 648.8 million were overweight. This has boosted sales of medical sensor monitoring and analysis equipment in homes and hospitals, driving growth in the industry. During the forecast period of 2017-2024, the international demand for wearable sensors is expected to grow rapidly [17]. In addition, increasing demand and acceptance of healthcare applications along with increasing government spending are some of the major factors expected to drive the global wearable biosensor market during the forecast period.[21]

II. Conclusions:

Biosensors are becoming increasingly popular due to their numerous applications. This technology is evolving at the same pace as demand. In my opinion, for a scientist to improve the quality of biosensors he should focus on three main factors.Specificity, detection limit, detection time. Biosensors have a bright future and are widely applied in screening inspection, food analysis, smart manufacturing, remote sensing, etc.

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