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A Review Article on Biosensors

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Research Article

Abstract: With the increasing threat of bioterrorism the detection of bio-agents has become a more challenging task. Thus, biosensors are the highly reliable and accurate solution to counteract these issues in current scenario. The biosensors are the combination of a transducer and the biological element. The transducer tends to change the bio signals and then calibrate it through a systemic scale. The researchers from different fields like physics, chemistry, material science, VLSI, have come up and have developed the more sensitive and reliable biosensors. Those biosensing devices also have vast number of applications in the field of biotechnology, medicine, agriculture, and even in bioterrorism. Different types of wireless sensors along with the case studies are produced in this article.

Keywords: Bioterrorism, bio- agents, biosensors, transducer, wireless sensor.

1. Introduction

The biosensors were first come to known in 1962 by L. C. Clark through the development of enzyme-based electrodes. In wide domain, the biosensors were defined as the biological recognition-based sensing device which is coupled with transducer and thus gives the development of biochemical parameters. It may also be referred to as an analytical device that deliberately incorporates in the recognition through the intimate combination of a biological element. The significant combination is of bio element and the sensor element that tends to recognize the 'analyte' and then transduces the change of the bio-molecules through electrical signal. The biosensor may also be thought as a combination of biological element along with the sensor element. The various combinations of the biological elements and the sensors are made to fit the different type of applications. In this way, the biosensors maybe used in several million of jobs with variable transducer-based mechanisms.

1.1 Variations in biosensors

There are multiple variations of bio sensors which are available for the different applications. On the basis of transducing mechanism, the biosensors may be classified as:

a. Ion- sensitive biosensors.
b. Resonance- sensitive biosensors.
c. Thermal- detection based biosensors.
d. Optical- detection based biosensors.
e. Electro- chemical biosensors.

The different configuration of the biosensors may be explained as follows:

1. The Membrane entrapment mode.
2. The Matrix entrapment mode.
3. The Physical adsorption mode.
4. The Covalent bonding mode.

In the membrane entrapment mode, there is a separation between the anayte and the sensor element, through a membrane called as semi permeable membrane and the sensor is attached to the bio- element. In the matrix entrapment mode, a porous entrapment through a matrix is prepared throughout the biological material and binds it over the entire sensor. However, the physical adsorption mode incorporates various forces like hydrophobic forces, Vander waal's forces, ionic forces etc. that attaches the sensor to the bio material [1]. Similarly, in the covalent bonding mode, the reactive group is attached to the bio- materials.

1.2 Classification of Biosensors

Biosensors are the components used for sensing the biological signals, which can further be classified as Affinity type biosensors and Catalytic type biosensors [2]. The affinity type of biosensors includes reception, antibodies along with the nucleic acids. However, the affinity type biosensors include are microbes, cells, enzymes, organelles, tissues, etc.

The schematic representation of biosensors may be shown as-

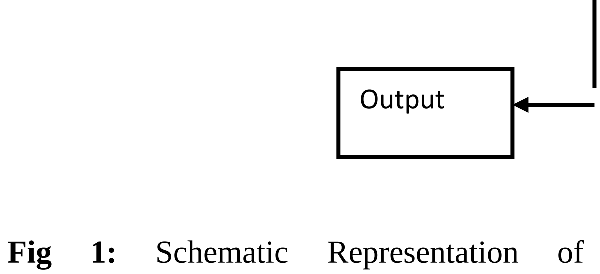

Fig 1: Schematic Representation of Biosensors.

1.3 Recent trends in biosensors

1. Qdots: Qdots are the Quantum Dots which are used in making the optical biosensors and ultra-stable with good Quantum confinement properties. They are also well known for their sensitive fluorescence on the chemical and physical interaction at the surface through direct activation or either through quenching [3,4]. They are sensitive in their measuring of pH, ions, biomolecules etc. However, the recent advancement of Qdots have found their applications in tissue engineering [5] for the detection of biomolecules and enzymes.

2. MEMS based biosensors: The different ways of incorporating mems in biosensors include magnetic, mechanical, optical and electrochemical biosensors. The mechanical MEMS are dependent on the surface stress the optical MEMS include the conjugation of ferromagnetic, paramagnetic, nanoparticles. However, the electrochemical MEMS use conductometric, ampero metric and potentiometric detection [6].

3. Graphene based biosensors: The graphene-based biosensors are also intended due to its properties that includes larger surface area, less production cost, higher conductivity and better electrochemical stability.

4. Non-Enzymatic Biosensors: This type of Biosensors includes the nonenzymatic biomolecules detection by using graphene-based electrodes and has a great number of advantages including low fabrication cost, long-term stability, high sensitivity, and even nano-composite based non enzymatic detection. The linear range of these biosensors is- 5–600 μM and the detection limit- 0.8 μM. Many researchers have also shown the derivation of chemical grapheme that can detect the dopamine with a linear range from 5 to 200 μM.

Biosensors in different domains

Biosensors towards Cell Morphology

Biosensors in detecting the cell morphology has got its application through tissue culture environments on the basis of the ECIS
Principle which is remarkably called as Electric Cell-substrate Impedance Sensing, by immersing the gold electrode in tissue culture medium where the cells get attached and are spread onto the electrodes, then the change in impedance is measured across the electrodes which finally leads to measure the behaviour of the cell in culture medium.
The *spreading* behaviour and the *attachment* of cells are important factors in this biosensor. The Normal cells, are attached to a surface before growing whereas, the cancer cells grow rapidly and show mitosis without getting attached. However, after attachment, the shape of the cells does not remain spherical but changes to the flat.

Detecting Pancreas Disorders

The holograms-based biosensors are being used as the sensing element for the pancreas detection. The BPTI enzymes, known as Bovine- pancreatic- trypsin inhibitor is used as a bioelement for screening the stool sample along with duodenal fluid and thus detecting the pancreatic disorder at comparatively low cost.

Detecting DNA

The biosensors which are used for the purpose of DNA detection are called as bio detectors. They are used to detect and characterise the antigens or the molecules of DNA by creating the multiple copies of DNA trough PCR. Also, FAB sensor, FDA are being used continuous monitoring of the biological agents. FABS are comparatively compact and fully automatic sensor that can even be remotely implemented. FAB also has the capability to detect the presence of bacteria, virus, toxin, etc.

Microfluidic Environment

Studies have also reported the applications for the micro-fluidic Devices and biosensor capabilities in tissue engineering. A multi parametric micro-physiometry has also been reported for monitoring the metabolism of human brain (T98G) cancer cells those which are cultured dynamic conditions [9]. An example of glass- micro fluidic device was used to facilitate the task of optical imaging and micro fabricated biosensors, in the cell chamber are being used for the upstream-downstream distributions.
Also to check the levels of oxygen consumption, pH values and the cell metabolites production of (lactate and glucose) were monitored by using external equipment (e.g., potentiostat). Similarly, (LAPS) light-addressable potentiometric sensor is being used in a microfluidic system for the monitoring of real time metabolism
in human breast cancer cells. Moreover, to study the adherent cells in tissue engineered constructs, impedance analysis is oftenly used where the cells are cultured on the surface of a micro-fabricated electrode and are exposed to the low-magnitude AC voltage and then the electrical impedance is measured in correlation to the cell parameters.

Future Directions

Due to the growing interest in biosensor research for various applications, the progress has remained limited. But there are numerous sensors including thermometric, optical, acoustic, electrochemical, piezoelectric and magnetic have been reported in various related literature that are easily available, showing great sensitivity and sensibility. Therefore, numerous applications can be felt by combining them to see the practical impact and the failure.

The Challenging applications of biosensors include miniaturization and the sensor-based integration with real time analysis and enormous open possibilities. Even though the sensitive, and real-time success capabilities will render the huge benefits to such systems and the full assessment of the parameters.

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