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Review on electrochemical biosensor

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Abstract
Electrochemical biosensors were the first of their kind scientifically proposed and massively commercialized biosensors available in different domains. Different aspects of these kinds of biosensors have been researched for a pretty long time. At present, the characteristics of biosensors changed a lot with the introduction of semiconductors and screen-printed electrodes. Biosensors are used in every aspect of human life and almost every industry. Its use in health and wellness, pollution monitoring, food quality monitoring, weather monitoring, wildlife surveillance, and diseases diagnosis is undeniable. In this review, we will discuss the principles and typical applications of electrochemical biosensors. The major challenges to scientists working on the development of electrochemical biosensors include (i) capturing signals (ii) the effective conversion of various signals to electrical, acoustic, gravimetric, or optical signals (this is called the transduction process) (iii) enhancing the performance of transducer by improving the sensitivity, quicker and sharper response time, and shorter detection limit, and (iv) minimizing the size of the bio-sensing devices further with the help of nanomaterial and nanotechnology.

Keywords: biosensors, nanomaterials, nanobiosensing, gold nanoparticles, carbon nanotubes, quantum dots, the enzyme electrode

Introduction

People in the modern age are enjoying various scientific and technological inventions that have made life easy on the earth. Appliances and gadgets such as smartphones, computers, air conditioning machines, and televisions are part and parcel of human life today. We are also using great inventions like television remotes, smoke detectors, remote-controlled electronic appliances, infrared thermometers, and hundreds of such devices in our personal and professional lives. Most of these technologically advanced devices or gadgets work seamlessly for years with accurate activity of these sensors. As such a "sensor" can be defined as a device that can detect one or more physical changes in the environment where it is placed. Such physical change can be a change in pressure, temperature, humidity, the flow of air, and a change in the flow of electricity [1, 2]. The sensor detects the change and sends signals to the rest of the part of the device. Again, a transducer is a tooling a sensor device that can convert one form of energy to another [3, 4]. In any automated measurement system, the sensor is considered the foundation. The quality and capability of the sensor determine the quality and perfectness of measurement. An ideal sensor possesses certain features such as range, drift, selectivity, sensitivity, resolution, calibration, reproducibility, and reaction time. With the advancement of technology, the importance of sensors is also increasing. Today, for various environments and technology, more advanced sensors are demanded. The use of sensors in monitoring unwanted movements, weather, wildlife activities, pollution level, food quality, and water levels in rivers and seas have made sensors more important than ever.

An electrochemical biosensor has remained a subject of elementary and applied research for nearly three decades. In 1962, Leland Clark invented the concept of enzyme-electrodes in the immobilized glucose oxidase environment. In the year 1975, biosensor Springs instruments were introduced in the market for commercial consumption. This device was good at detecting blood sugar levels in the blood samples. Today, hundreds of commercialized electrochemical biosensors are available in the market [5].

One of the vital aspects of an electrochemical biosensor is the existence of an enzyme on the bio-recognition layer of the device. This enzyme must be suitable for developing measurable signals for the transducers. Anative enzyme is frequently used for this purpose. In this case, the analyte is the same as the enzyme-substrate. Again, it can also act as an purposeful inhibitor. Again, there are affinity-based sensors that have slightly different modeling. In affinity-based sensors, enzymes are used as labels that are embedded to antibodies or antigens in a predetermined system. Sometimes, oligonucleotides are also used instead of antibodies or antigens or used in combination with antibodies or antigens [6].

Some enzymes are processed for biosensors for monitoring some clinical metabolites specifically. The most important metabolites that were processed with these enzymes mainly belonged to oxide reeducates group such as glucose oxidase and dehydrogenase required for glucose assays [7], NADH-based lactate dehydrogenase [8], alcohol oxidase used for ethanol [9], urease for urea [10], and cholesterol oxidase that is immobilized with cholesterol-based esterase used for cholesterol assay [11].

Review of Literature

In the electrochemical biosensors there are two parts, viz. working electrode and counter electrode. When current flows in the system due to electrochemical transductions, the difference in the flow is captured immediately. The analyte in the system acts as a detector and relays the change in the form of electrical signals. Depending on the target analyte types, different types of transducers are used in electrochemical biosensors. A transducer could be ion-charged, potentiometric, amperometric, field-effect kind, or conducto metric. Different qualities of nanomaterials are used in designing these kinds of biosensors [12].

Electrochemical biosensors have multiple benefits over other kinds of sensors. These are cost-effective, easy to use, and compact. In healthcare, its use has revolutionized the diagnosis processes of several diseases. Devices such as blood sugar measurement devices can be self-administered. Blood is collected on a strip that contains an amperometric electrode that acts as a glucose biosensor. This technology is now widely used all over the world for clinical detection of various cancers that helps in the primary diagnosis and clinical decisions for treatments [13-14].

Another remarkable invention is STAT clinical analyzer. In this analyzer, a single chip is used to integrate several electrochemical analysis-based technologies for the examination of quantifiable cancer analytes for different chemical compounds. Here the sensing layer contains antibody-based electrochemical that is capable of sensing malignancy of targeted tissues or deformed cells in the blood. These kinds of sensors are highly efficient and responsive. In a device like STAT analyzer, an array of electrochemical potentiometric devices, conductivity or impedimetric devices, amperometric devices, and transducers are included and integrated into a small place [15].

The concept behind electrochemical biosensors is integrating the electro-analytical process with biological components. Based on the process of bio sensitivity, these sensors can be divided into two different categories: (i) Bio-Catalytic sensors and (ii) Affinity sensors. In a device that contains bio-catalytic sensors, an analyte can be a tissue, certain group of cells, enzymes, or antigens [16]. In a device that contains an affinity sensor, an analyte can be a receptor or an antibody's nucleic acid [17].

Conclusion

Over the past few decades, many changes have been made in electrochemical biosensors. With each evolution, the application of these sensors has increased manifold. It seems that these kinds of sensors have a promising future in the coming time. Selectivity and sensitivity are two important aspects of biosensors that work with the help of electrochemical. Enhanced selectivity and sensitivity will make these devices more useful in the future. Nanotechnology is helping to minimize the size of the sensors making the devices more sophisticated and advantageous in different environments. At the same time, the efficiency of the electrochemical biosensors has multiplied in recent times. The devices can measure the changes or deviations rapidly accepting the minimum volume of a sample.

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