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Biosensors: Principles, Classification and Applications

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Abstract: *Biosensors are the promising analytical device which detects the various types of pollutants. Normally biosensors consist the biological component connected to the transducer. In present report we have been presented the basic theory of the biosensors. The construction and its working principles have been presented thoroughly. The classification of the biosensors also discussed in present paper. Lastly, we have been discussed the applications of the biosensors.*

Index Terms *– Biosensor, Bioreceptor, Transducer, Application of biosensors.*

1. INTRODUCTION

Different types of diseases are infected to the human beings due to the different types of biomolecules such as urea, glucose, cholesterol etc. The pre information of these biomolecules are necessary to control and diagnosis the various types of diseases. Therefore, it is very important to keep concentration on the level of different biomolecules in human body serum [1]. The traditional processes are troublesome with of sampling, preparation, and measurement creates a lapse between the time an analytical value is determined. A continuous quantitative and qualitative analysis, thereby eliminating the time lapse, while preserving the precision and accuracy of laboratory analysis is to be developed [2]. For, the measurement of various biomolecules in the human body serum firstly biosensors were invented by Clark in 1956 and Clark and Lyons in 1962 for determination of glucose [3]. Actually, the biosensors were found in scientific literature in the late 1970s. Generally, a biosensor is an analytical device that determines the concentration of the analyte (quantity which is to be detect or measure) through a chemical interaction with a bio-recognition element via a output signal (may be electrical, intensity of light, or any other types of signal). Without a doubt, the advancement of biosensor technology in recent years has made an important contribution to the safeguarding of people's health and ecological systems. Regrettably, biosensors have not been as successful as expected, and there is a challenge in comprehensive framework, more expense, and more reputable equipment [4,5].

2. BIOSENSOR

"A biosensor is a self-contained integrated device that can provide specific quantitative or semi-quantitative analytical information using a biological recognition element (biochemical receptor) that is in direct spatial contact with a transducer element," according to a recently proposed IUPAC definition. A biosensor should be differentiated from a bioanalytical system, which requires additional steps such as reagent addition. Furthermore, a biosensor should be distinguished from a bio probe, which is either disposable after one measurement, i.e., single use, or incapable of continuously monitoring analyte concentration" [6,7]. The first biosensor for measuring glucose was an enzyme electrode, which later evolved into the blood glucose metre used by diabetics today. Biosensors, bioanalytical systems, and single-use biosensors can all be distinguished. A bioanalytical system necessitates additional processing steps (such as reagent addition), whereas a single-use biosensor (e.g., pregnancy test, glucose metre test strip) is disposable and cannot continuously monitor analyte concentration. However, the scientific community generally refers to a biosensor as an analytical device that combines a biochemical element with a transducer element to convert the response into an electronic signal [8]. The mode of biosensor transduction could be optical, electrochemical, or piezoelectric, which means that photons, electrons, or resonance frequency could be measured. In general, a biosensor employs a biological recognition element that detects the presence of an analyte and generates a physical or chemical response that is converted to a signal by a transducer [9]. Figure 1 depicts the general block diagram of a biosensor system.

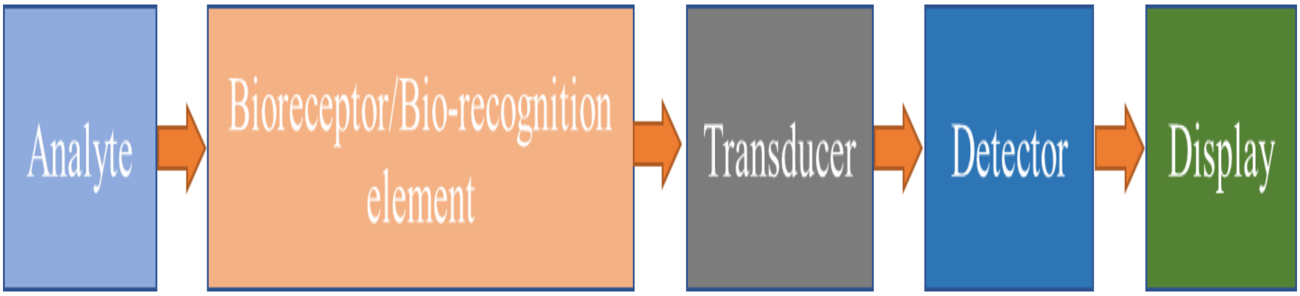

Fig.1. General Biosensor System

3. CLASSIFICATION OF BIOSENSOR

Biosensors can be classified according to either the nature of the bioreceptor element or the principle of operation of the transducer as shown in Fig. 2;

3.1 ACCORDING TO BIORECEPTOR

A biosensor's most crucial and important part is bioreceptor or biological recognition element. The bioreceptor compromises a sensor's recognition system for the target analyte. To prevent interference from other substances in the sample matrix, a bioreceptor must be selective and sensitive to the specific target analyte [10]. According, to work function and reactivity, the biomolecules used for the development of biosensors can be classified mainly into five groups are as;

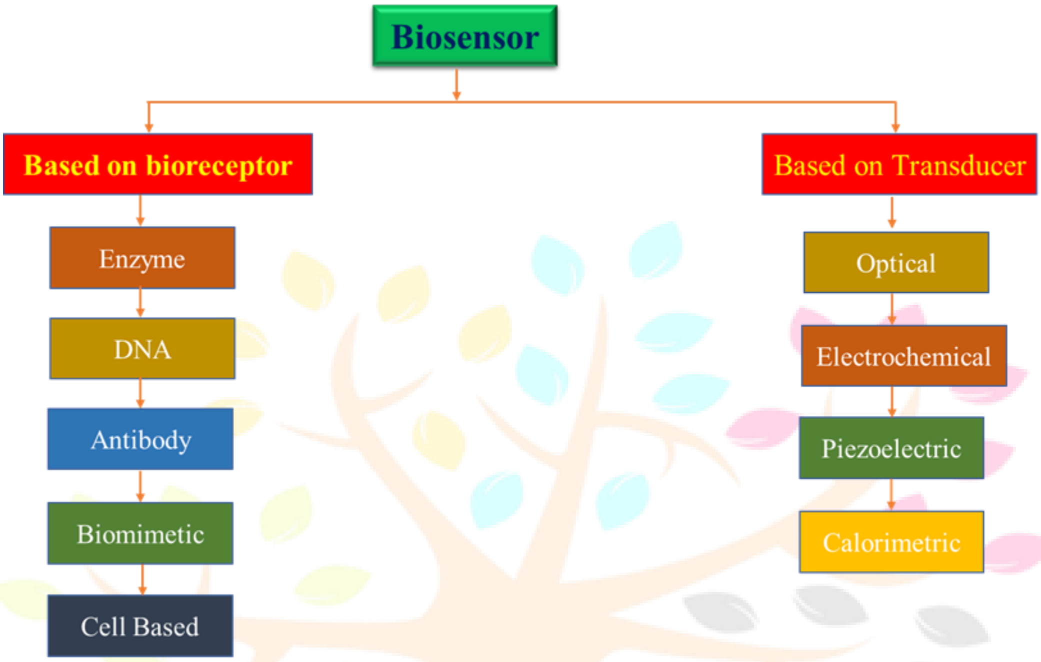

Fig. 2 Classification of Biosensor

3.1.1 ENZYMES BASED

Enzymes are proteins that catalyse specific chemical receptor during the reaction. These can be used in a purified form or be present in a microorganism or in a slice of intact tissue. The mechanisms of operation of these bioreceptors can involve: conversion of the analyte into a biosensor-detectable product, detection of an analyte that acts as enzyme inhibitor or activator, or evaluation of the modification of enzyme properties upon interaction with the analyte [11].

3.1.2 ANTIBODIES AND ANTIGENS BASED

An antigen is a biomolecule that triggers the immune response of an organism to produce an antibody, a glycoprotein produced by lymphocyte B cells, which will specifically recognize the antigen that stimulated its production [12].

3.1.3 NUCLEIC ACIDS BASED

The recognition process is based on the complementarily of base pairs (adenine and thymine or cytosine and guanine) of adjacent strands in the double helix of DNA. These biosensors are usually known as geno biosensors. Alternatively, interaction of small pollutants with DNA can generate the recognition signal [13].

3.1.4 WHOLE CELLS BASED

The whole microorganism or a specific cellular component, for example a non-catalytic receptor protein, is used as the biorecognition element [14].

3.1.5 BIOMIMETIC RECEPTORS BASED

Recognition is achieved by use of receptors, for instance, genetically engineered molecules, artificial membranes, or molecularly imprinted polymers (MIP), that mimic a bioreceptor. The most recent investigations in artificial receptors include application of a combined approach of computer (molecular) modelling and MIP and the application of combinatorial synthesis for the development of new sensing layers [15].

3.2 ACCORDING TO TRANSDUCER

Transducers are used to transform the one form of energy into another form. Transducers are the crucial part of biosensors. The main types of transducers used in the development of biosensors can be divided into four groups: optical, electrochemical, piezoelectric, calorimetric etc.

3.2.1 OPTICAL

This method of transduction has been employed in many classes of biosensor due to the many different types of spectroscopies such as absorption, fluorescence, phosphorescence, Raman, SERS, refraction and dispersion spectroscopy. These transduction methods are capable of measuring different properties of the analyte. The optical based biosensor is able to provide label free, real time and parallel detection [16].

3.2.2 ELECTROCHEMICAL

The electrochemical biosensor, in which an electrode is used as the transduction element, represents an important subclass of biosensors. According to an IUPAC recommendation in 1999, an electrochemical biosensor is a self-contained integrated device, which is capable of providing specific quantitative or semi-quantitative analytical information using a biological recognition element (biochemical receptor) which is kept in direct spatial contact with an electrochemical transduction element. Electrochemical biosensors measure the current produced from oxidation and reduction reactions. The current produced can be correlated to either the concentration of the electro active species present or its rate of production. The resulting electrical signal is related to the recognition process by target and analyte, and is proportional to the analyte concentration [17].

3.2.3 PIEZOELECTRIC

In piezoelectric biosensors, the transducer is made of piezoelectric material (e.g., quartz) and the biosensing material is coated with the piezoelectric material, which vibrates at a natural frequency. The frequency is controlled by an external electrical signal, which produces a certain value of current, and when the target analyte is exposed to the sensing material the reaction will cause a frequency shift, which will produce changes in the current reading that can be collated to the mass of the analyte of interest [18].

3.2.4 CALORIMETRIC

The calorimetric principle involves the measurement of the changes in temperature in the reaction between the biorecognition element and a suitable analyte. This change in temperature can be correlated to the amount of reactants consumed or products formed. The major advantages of this type of thermal detection are the stability, increased sensitivity and the possibility of miniaturation. In the calorimetric device, the heat change is measured using either a thermistor (usually metal oxide) or thermopile (usually ceramic semiconductor) [19].

4. APPLICATIONS OF BIOSENSOR

4.1 CLINICAL DIAGNOSIS

Biosensor development made a huge progress in recent years, and glucose biosensor is most common application in clinical diagnosis. Glucose is one the main cause in many diseases, such as diabetes and other endocrine metabolic disorders, to monitor the glucose level in blood, glucose biosensor plays very important role [20].

4.2 FOOD CONTROL

Food serves as a growth medium for microorganisms that can be pathogenic or cause food spoilage. Optical biosensors show greater potential for the detection of pathogens, pesticide and drug residues, hygiene monitoring, heavy metals and other toxic substances in the food to check whether it is safe for consumption or not [21].

4.3 ENVIRONMENTAL SCREENING

Industrial and urban wastewater contains toxic substances and causes environmental pollution. Due to this, lot of bioassays and biosensors for toxicity evaluation were developed in recent years [22].

5. CONCLUSION

In present study we have demonstrated the basic principle of biosensor. The different types of biosensors based on two criteria i.e., based on bioreceptor species and used transducers. All types of biosensors briefly discussed in different sections. Lastly, some applications of the biosensors have been discussed.

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