Biosensors

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INTRODUCTION

Biosensor[1] is a diagnostic tool in which a biological element is used to sense a chemical and its amount in a given sample, and then the sensed information (i.e., data) is transferred to a transducer which converts this signal to electrical signal. In this way, it transforms a biological response into an electrical signal. It also detects, records, and transmits data generated due to physiological change or any chemicals presence in the area being analyzed. The analysis is accurate and reliable.

In other words, biosensor can be termed as a device used in a biological derived sensing element[2] integrated with a physiochemical transducer, producing an electrical signal (Turner, 1996). The resulting electrical signal is a measure of the amount of chemical or combination of chemicals being detected.

Sometimes Biosensors are referred as the living organisms, which are used as a sensor to detect the environmental change.

BACKGROUND[2]

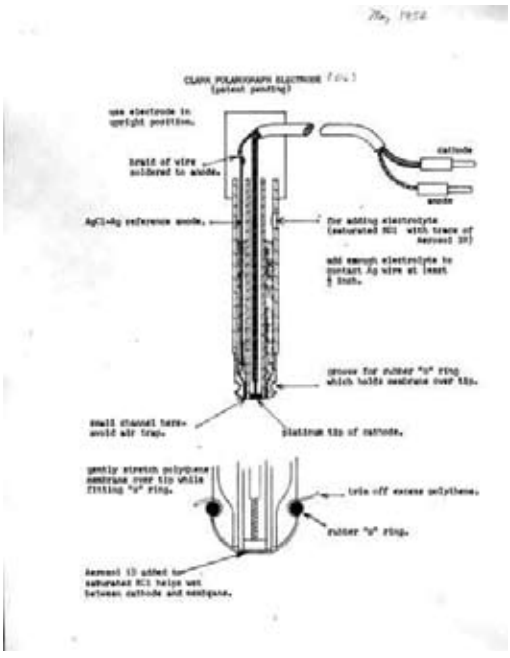
Professor Leland C. Clark Jr. led the foundation of biosensor concept. He was a pioneer in this field. His name will always remain embedded with the concept of *Artificial Blood*[3]. In 1956, Clark ignited the biosensor concept by publishing one of his revolutionary papers on the oxygen electrode (Figure 1).

Soon, Clark invented a device to rapidly determine the amount of glucose present in the blood at a given instant of time. In 1962, at the New York Academy of Sciences symposium, based on his experience and addressing his desire to expand the range of analytes that could be measured in the body, he made an ineffaceable mark by describing how to make electrochemical sensors more intelligent by adding enzyme transducers as membrane enclosed sandwiches. After that, Guilbault and Montalvo described a potentiometric enzyme electrode to sense urea, based on urease immobilized at an ammonium-selective liquid membrane electrode. In 1974, thermal transducers for biosensors were proposed, and were named as thermal enzyme probes and enzyme thermistors respectively.

Soon, Clark's spark was turned into fire in 1975 with the successful launch of Yellow Springs Instruments Company glucose analyzer, based on the amperometric detection of hydrogen peroxide. In the same year, a paper regarding utilizing bacteria as the biological element in microbial electrodes for the measurement of alcohol was presented by Divis. Later, during the same year, Lubbers and Opitz introduced the term "optode" to describe a fiber-optic sensor with immobilized indicator to measure Carbon dioxide or oxygen. Commercial optodes are very well used in vivo measurements of pH, pCO_2 and pO_2. After that, a lot of ideas were floating, but as the time passed, they sank.

In 1982, Shichiri was the first one to describe the first needle-type enzyme electrode for subcutaneous implantation. In 1984, Cranfield Biotechnology Centre, from Cranfield University, published a paper on the use

Figure 1. The Clark polarograph electrode



of ferrocene and its derivatives as an immobilized mediator for use with oxidoreductases in the construction of inexpensive enzyme electrodes. In 1987, based on this, MediSense (Cambridge, USA) launched screen-printed enzyme electrodes with a pen-sized mater for home blood-glucose monitoring. Today, 18.2 millions of diabetic people in USA[4] depend on Clark's original glucose sensor concept for self-monitoring.

BASIC STRUCTURE OF BIOSENSOR[5]

Biosensor comprises of a biological element which is connected to a transducer, which in turn is connected to electronics, which can process the received information, and then finally display it. The illustrated version has been demonstrated in Figure 2.

A most common example of a biosensor for the detection of glucose in a sample (blood) can be seen in Figure 3.

Glucose oxidase enzyme (GOx) in glucose molecule is converted to hydrogen peroxide (H_2O_2) and gluconic acid ($C_6H_{12}O_7$) within the biolayer. The H_2O_2 passes through all the layers in the path, and is detected at platinum electrode. The electrode senses it, and the current is thus produced, which is then processed further, and is passed on to the display unit to show the concentration of glucose in given sample.

CLASSIFICATION OF BIOSENSORS[5]

Broadly biosensors can be classified according to Transducers, bioactive components, or immobilization techniques used in the biosensor. Detailed classification of Biosensors has been illustrated in Figure 4, 5 and 6.

Transducer used can be Electromechanical, optical, piezo-electrical, or thermal. Bioactive components can be enzymes, antibodies, cells, nucleic acids, or lipids. Immobilization techniques can be physical or chemical.

CURRENT AND FUTURE DEVELOPMENTS IN BIOSENSORS

Biosensor is the one of the most rapidly growing fields now-a-days. Its current developments and focus is mainly towards the health care area. In spite of its tremendous potential, many of the developments in Biosensors are still not commercialized. As of now, mostly single analyte devices are present; however, in the future, multianalyte sensor will be there. Research and development in biosensor field is very rapid, and lot of potential is there in coming years:

- Routine analytical measurement of folic acid, biotin, vitamin B12, and pantothenic acid[6].
- Remote sensing of airborne bacteria (e.g., in counter-bioterrorist activities[6]).
- Most of the research is going on in the development of noninvasive devices strips to diagnose diseases[7].
- Medical telesensor is in development phase, consisting of an array of chips to collectively monitor bodily function such as blood pressure, oxygen level, pulse rate, and body temperature[8].

Figure 2. Basic structure of biosensor (Source: http://intel.ucc.ie/sensors/Biosens.htm)