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Biosensor Types and Its Applications

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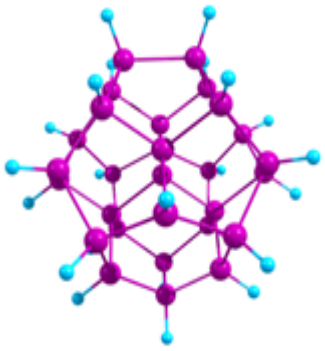
Introduction

A biosensor is an analytical device, used for the detection of an analyte that combines a biological component with a physicochemical detector.
Biosensors harness the immensely powerful molecular recognition properties of living systems and engineer these into electronic devices to provide easy-to-use sensing devices.

The two most successful biosensors to date are Mediated amperometric glucose biosensor and Real-time bio affinity interaction analysis.
As a result of recent scientific and technological progress, devices like biosensor are likely to play an increasingly important role in generating analytical information in all sectors of human endeavor, from medicine to the military. In particular, biosensors will form the basis of cheap, simple devices for acquiring chemical information, bringing sophisticated analytical capabilities to the non-specialist and general public alike. The market opportunities for the rapid exploitation of novel developments in this sector are substantial. Biosensor research is also likely to have a significant impact on the development of modern electronics.

A common example of a commercial biosensor is the blood glucosebiosensor, which uses the enzyme glucose oxidase to break blood glucose down. In doing so it first oxidizes glucose and uses two electrons to reduce the FAD (a component of the enzyme) to FADH2. This in turn is oxidized by the electrode in a number of steps. The resulting current is a measure of the concentration of glucose. In this case, the electrode is the transducer and the enzyme is the biologically active component.



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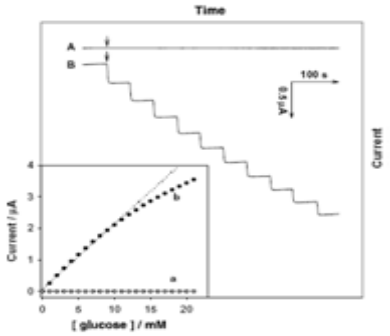
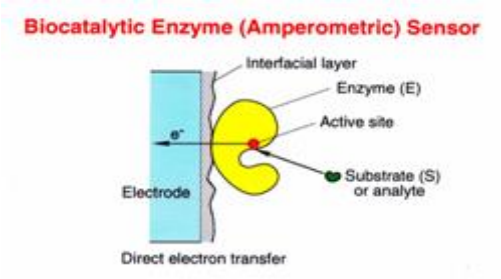
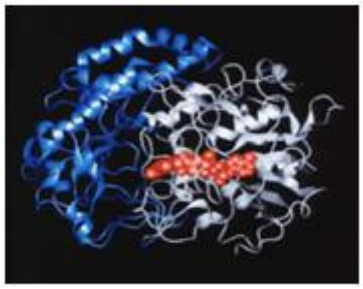
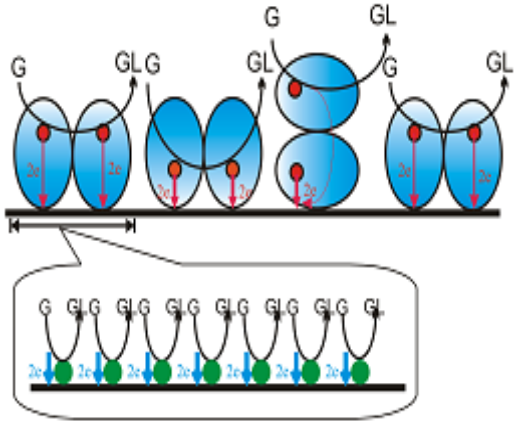








Basic Principle of Biosensor

Basic principle of biosensor involved in three elements:

- First biological recognition element which highly specific towards the biological material analytes produces.
- Second transducers detect and transduces signal from biological target receptor molecule to electrical signal which is due to reaction occur.
- Third after transduction signal from biological to electrical signal where its amplification is necessary and takes place and read out in detector after processing the values are displayed for monitor and controlling the system.

Basic Characteristics of Biosensor

1. Linearity

Linearity of the sensor should be high for the detection of high substrate concentration.

2. Sensitivity

Value of the electrode response per substrate concentration.

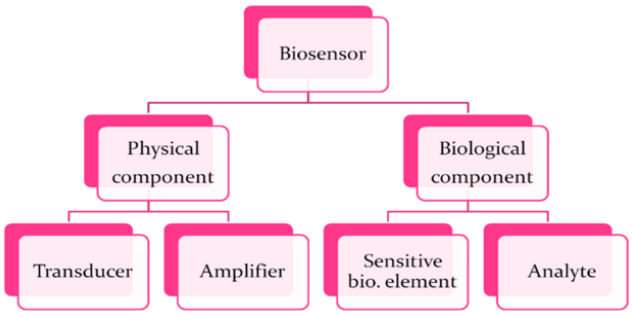
3. Selectivity

Chemicals interference must be minimized for obtaining the correct result.

4. Response Time

Time necessary for having 95% of the response.

Components



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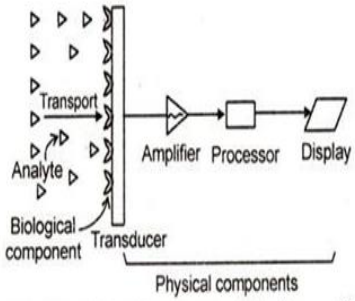
There are two main types of components of Biosensor that is Physical and Biological Component.

Physical Components



A schematic representation of the various components of a biosensor. The biological component may be enzyme, nucleic acid, antibody, etc. The analyte must be transported from the solution to the biological component for the reaction, ordinarily the transport is due to simple diffusion.

Transducer

The biological component interacts specifically to the analyte, which produced a physical change close to the transducer surface.Transducer detects & measures this change and converts it into an electrical signal. Transducer work in a physicochemical way, optical way, piezoelectric way, electrochemical way etc.

Amplifier

An amplifieris an electronic device that increases the powerof a signal.

It does this by taking energy from a power supplyand controlling the output to match the input signal shape but with a larger amplitude. In this sense, an amplifier modulates the output of the power supply to make the output signal stronger than the input signal.

Biological Components

Analyte

An analyte is a compound whose concentration is to be determined by the biosensor. When the nature of interaction between the analyteand the biological material is made, the biosensor may be of two types – The analyte which may be converted into a new chemical molecule, such biosensor are called CATALYTIC BIOSENSOR.

The analyte which may simply bind to the biological material, this biosensor are known as AFFINITY BIOSENSOR.

Sensitive Biological Element

Biological element a biologically derived material or can be created by biological engineering. Biological element is like tissue, cell receptor, enzymes, antibodies, nucleic acid etc. The biological component of biosensor performs the following two key functions –

It specifically recognizes the analyte.

Interacts with it in such a manner, which produces some physical change detectable by the transducer.

Types of Biosensors

The biosensors are of 5 types:

1. Calorimetric Biosensors:

Many enzyme catalyzed reactions are exothermic. Calorimetric biosensors measure the temperature change of the solution containing the analyte following enzyme action and interpret it in terms of the analyte concentration in the solution. The analyte solution is passed through a small packed bed column containing immobilized enzyme; the temperature of the solution is determined just before entry of the solution into the column and just as it is leaving the column using separate thermistors.

This is the most generally applicable type of biosensor, and it can be used for turbid and strongly coloured solutions. The greatest disadvantage is to maintain the temperature of the sample stream, say ± 0.01° C, temperature. The sensitivity and the range of such biosensors is quite low for most applications. The sensitivity can be increased by using two or more enzymes of the pathway in the biosensor to link several reactions to increase the heat output. Alternatively, multifunctional enzymes may be used. An example is the use of glucose oxidase for determination of glucose.

2. Potentiometric Biosensors:

These biosensors use ion-selective electrodes to convert the biological reaction into electronic signal. The electrodes employed are most commonly pH meter glass electrodes (for cations), glass pH electrodes coated with a gas selective membrane (for

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CO2, NH, or H2S) or solid state electrodes. Many reactions generate or use H+ which is detected and measured by the biosensor; in such cases very weak buffered solutions are used. Gas sensing electrodes detect and measure the amount of gas produced. An example of such an electrodes is based on urease which catalyses the following reactions:

$CO(NH2)2 + 2H2O + H+ \rightarrow 2NH4+ + HCO–3$

This reaction can be measured by a pH sensitive, ammonium ion sensitive, NH3 sensitive or CO2 sensitive electrode. Biosensors can now be prepared by placing enzyme coated membranes on the ion-selective gates of ion-selective filed effect transistors; these biosensors are extremely small.

3. Acoustic Wave Biosensors:

These are also called piezoelectric devices. Their surface is usually coated with antibodies which bind to the complementary antigen present in the sample solution. This leads to increased mass which reduces their vibrational frequency; this change is used to determine the amount of antigen present in the sample solution.

4. Amperometric Biosensors:

These electrodes function by the production of a current when potential is applied between two electrodes, the magnitude of current being proportional to the substrate concentration. The simplest amperometric biosensors use the Clark oxygen electrode which determines the reduction of O2 present in the sample (analyte) solution. These are the first generation biosensors. These biosensors are used to measure redox reactions, a typical example being the determination of glucose using glucose oxidase.

A major problem of such biosensors is their dependence on the dissolved O2 concentration in the analyte solution. This may be overcome by using mediators; these molecules transfer the electrons generated by the reaction directly to the electrode rather than reducing the O2 dissolved in analyte solution. These are also called second generation biosensors. The present day electrodes, however, remove the electrons directly from the reduced enzymes without the help of mediators, and are coated with electrically conducting organic salts.

5. Optical Biosensors:

These biosensors measure both catalytic and affinity reactions. They measure a change in fluorescence or in absorbance caused by the products generated by catalytic reactions. Alternatively, they measure the changes induced in the intrinsic optical properties of the biosensor surface due to loading on it of dielectric molecules like protein (in case of affinity reactions). A most promising biosensor involving luminescence uses firefly enzyme luciferase for detection of bacteria in food or clinical samples. The bacteria are specifically lysed to release ATP, which is used by luciferase in the presence of 02 to produce light which is measured by the biosensor.

Current Research and Trends

Because in many cases the transduction technology is well established, most of the research is focused on improving immobilization techniques of the biological element to increase sensitivity, selectivity, and stability. While critical, the latter has received relatively little attention probably in part because there is a tendency to design disposable devices that are most useful in quality assurance laboratories but do not allow on-line implementation for process control.

Another dynamic area of research is miniaturization of sensors and flow systems. Development of these technologies is mainly driven by the need for in vivo applications for medical diagnosis and may not find immediate use in the agricultural and food industries. After almost 40 yr of research in biosensors, a wide gap between research and application is evident. The lack of validation, standardization, and certification of biosensors has resulted in a very slow transfer of technology. With faster computers and automated systems this process should accelerate in the future.

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