BIOSENSORS: PRINCIPLE, TYPES AND APPLICATIONS

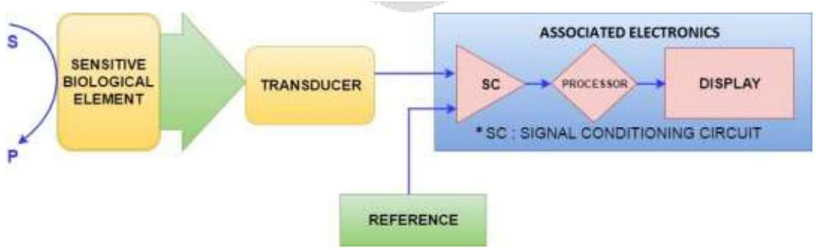

Fig -1: Schematic diagram showing main components of a biosensor

Principle of a Biosensor

The desired biological material (usually a specific enzyme) is immobilized by conventional methods (physical or membrane entrapment, non- covalent or covalent binding). This immobilized biological material is in intimate contact with the transducer. The analyte binds to the biological material to form a bound analyte which in turn produces the electronic response that can be measured. In some instances, the analyte is converted to a product which may be associated with the release of heat, gas (oxygen), electrons or hydrogen ions. The transducer can convert the product linked changes into electrical signals which can be amplified and measured.

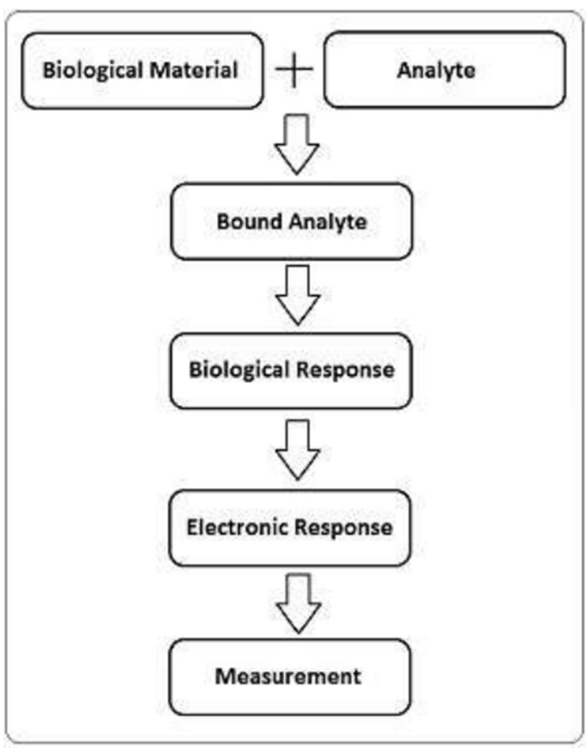

Fig -2: Measurement flow for a biosensor

Working of a Biosensor

The electrical signal from the transducer is often low and superimposed upon a relatively high and noisy (i.e. containing a high frequency signal component of an apparently random nature, due to electrical interference or generated within the electronic components of the transducer) baseline. The signal processing normally involves subtracting a 'reference' baseline signal, derived from a similar transducer without any biocatalyst membrane, from the sample signal, amplifying the resultant signal difference and electronically filtering (smoothing) out the unwanted signal noise. The relatively slow nature of the biosensor response considerably eases the problem of electrical noise filtration. The analogue signal produced at this stage may be output directly but is usually converted to a digital signal and passed to a microprocessor stage where the data is processed, manipulated to desired units and output to a display device or data store.

TECHNOLOGY USED FOR TRANSDUCER IN BIOSENSORS

The technology used for transducer can be any one of the four types listed below and depend upon the biological sensor used. In biosensors, suitable transducers are designed, keeping in view the following:

(i) Specific desired interaction between the analyte and the biological elements;

(ii) The intended use of the biosensors and the

(iii) Manufacturing cost of the device.

TYPES OF BIOSENSORS

Biosensors can be grouped according to their biological element or their transduction element. Biological elements include enzymes, antibodies, micro-organisms, biological tissue, and organelles. The method of transduction depends on the type of physicochemical change resulting from the sensing event. Primarily biosensors based on transducer element are mass based (piezoelectric, etc), electrochemical biosensors (potentiometric, amperometric, etc), and optical types of biosensors (fiber optics, etc).

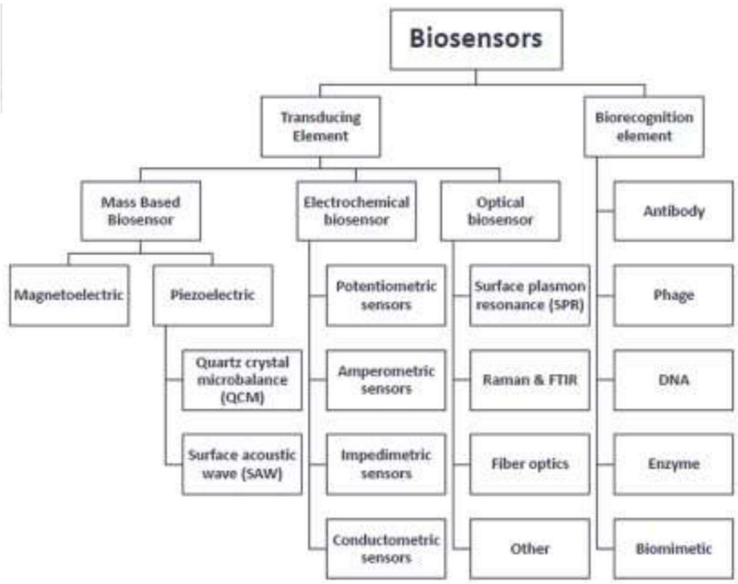

Fig: Classification of biosensors based on the transducer element & bio-recognition element

5. BIOSENSORS AND THEIR USES

Biosensors can be broadly classified as follows, based on the principle involved.

A. Piezoelectric Sensors:

Piezoelectric biosensors are considered as mass-based biosensors. Piezoelectric biosensors are based on the principle of acoustics (sound vibrations), hence they are also called as acoustic biosensors. Piezoelectric biosensors produce an electrical signal when a mechanical force is applied. In this mode, sensing molecules are attached to a piezoelectric surface - a mass to frequency transducer - in which interactions between the analyte and the sensing molecules set up mechanical vibrations that can be translated into an electrical signal proportional to the amount of the analyte. Example of piezoelectric sensor is quartz crystal micro or nano balance.

B. Electrochemical Sensors:

Electrochemical biosensors have been the subject of basic as well as applied research for nearly fifty years. Leland C. Clark introduced the principle of the first enzyme electrode with immobilized glucose oxidase at the New York Academy of Sciences Symposium in 1962. In this configuration, sensing molecules are either coated onto or covalently bonded to a probe surface. A membrane holds the sensing molecules in place, excluding interfering species from the analyte solution. The sensing molecules react specifically with compounds to be detected, sparking an electrical signal proportional to the concentration of the analyte. Based on their operating principle, the electrochemical biosensors can employ potentiometric, amperometric and impedimetric transducers converting the chemical information into a measurable amperometric signal.

C. Optical Sensors:

In optical biosensors, the optical fibers allow detection of analytes on the basis of absorption, fluorescence or light scattering. Here both catalytic and affinity reactions can be measured. The reaction causes a change in fluorescence or absorbance resulting due to change in the refractive index of the surface between two media which differ in density. For instance, if antibodies bind on a metal layer, the refractive index of the medium in contact with this layer will change. Since they are non-electrical, optical biosensors have the advantages of lending themselves to in vivo applications and allowing multiple analytes to be detected by using different monitoring wavelengths. The versatility of fiber optics probes is due to their capacity to transmit signals that reports on changes in wavelength, wave propagation, time, intensity, distribution of the spectrum, or polarity of the light.

6. APPLICATIONS OF BIOSENSORS IN VARIOUS FIELDS

The advantages of biosensors include low cost, small size, quick and easy use, as well as a sensitivity and selectivity greater than the current instruments. Biosensors have many uses in clinical analysis, general health care monitoring. The most popular example is glucose oxidase-based sensor used by individuals suffering from diabetes to monitor glucose levels in blood. Biosensors have found potential applications in the industrial processing and monitoring, environmental pollution control, also in agricultural and food industries. The introduction of suitable biosensors would have considerable impact in the following areas:

A. Clinical and Diagnostic Applications:

B. Industrial Applications:

C. Environmental Monitoring:

D. Agricultural Industry:

E. Food Industry: