THE FINAL WORD

The official e-newsletter of Industrial chemistry(IC) department, V.V.Nagar, Anand, Gujarat

BIOSENSOR

Sensor:

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

Human beings have at least five of these, i.e. - noses, tongues, ears, eyes and skin. They represent the main types of sensor. In the laboratory, one of the best known types of sensor is the litmus paper test for acids and alkalis, which gives a qualitative indication, by means of a colour reaction, of the presence or absence of an acid. A more precise method of measuring acidity is the use of the pH meter, which is an electrochemical device giving an electrical response which can be read by a needle moving on a scale or on a digital read-out device or input to a microprocessor.

Biosensor:

A biosensor is an analytical device which converts a biological response into an electrical signal. A biosensor according to IUPAC recommendations 1999, a biosensor is an independently integrated receptor transducer device, which is capable of providing selective quantitative or semi-quantitative analytical information using a biological recognition element.

Basic Concept:

The purpose of a biosensor is to provide rapid, real-time, accurate and reliable information about the analyte of interrogation. Biosensors have been envisioned to play a significant analytical role in medicine, agriculture, food safety, homeland security, bioprocessing, environmental and industrial monitoring.

A biosensor consists of three main elements, a bioreceptor, a transducer and a signal processing system. A biological recognition element or bioreceptor is generally consists of an immobilized biocomponent that is able to detect the specific target analyte. This biocomponents are mainly composed of antibodies, nucleic acids, enzyme, cell and etc. Transducer in the other hand is a converter.

The reaction between the analyte and bioreceptor bring about a chemical changes such as the production of a new chemical, release of heat, flow of electrons and changes in pH or mass. The biochemical signal is converted into an electrical signal by the transducer. Eventually, signal processing where the electrical signal is amplified and sent to a microelectronics and data processor. A measurable signal is produced, such as digital display or print-out.

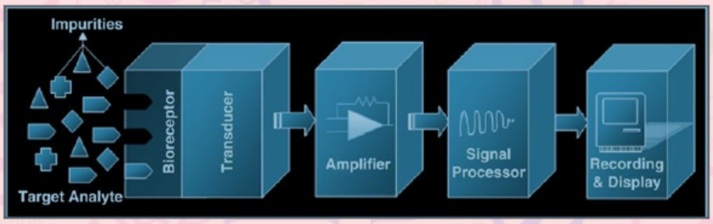

Fig. 1 shows a schematic diagram of the typical components in a biosensor.

The key part of a biosensor is the transducer which makes use of a physical change accompanying the reaction. This may be-

- ➔ The heat output (or absorbed) by the reaction (calorimetric biosensors),
- ➔ Changes in the distribution of charges causing an electrical potential to be produced (potentiometric biosensors),
- ➔ Movement of electrons produced in a redox reaction (amperometric biosensors),
- ➔ Light output during the reaction or a light absorbance difference between the reactants and products (optical biosensors),
- ➔ Effects due to the mass of the reactants or products (piezo-electric biosensors).

Bio sensors are divided into 3 generation depending upon their integration level:-

➢ First generation

In the simplest approach the biocatalyst is entrapped between or bound to membranes and this arrangement is fixed upon the surface of the transducer.

➢ Second generation

The immediate adsorptive or covalent fixation of the biologically active component to the transducer's surface permits the elimination of the semi permeable membrane.

➢ Third generation

The direct binding of the biocatalyst to an electronic device that transducers and amplifies the signal.

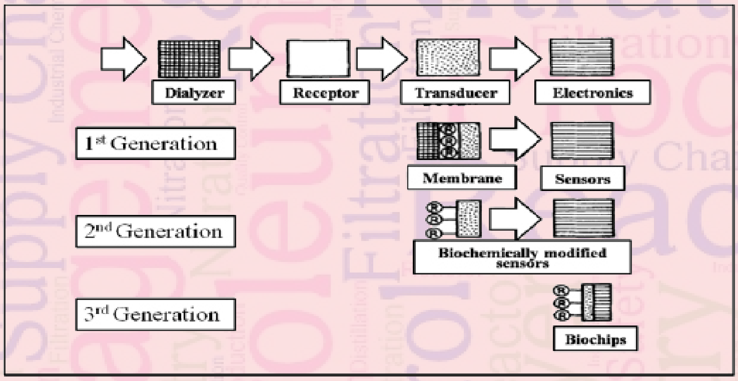

Fig. 2 Generations of biosensors

Applications

Bio sensors have been applied in many fields namely food industry, medical field, marine sector etc., and they provide better stability and sensitivity as compared with the traditional methods.

➢ In food processing, monitoring, food authenticity, quality and safety:

Food authentication and monitoring with objective and consistent measurement of food products, in a cost effective manner, are desirable for the food industry. Thus development of biosensors in response to the demand for simple, real-time, selective and inexpensive techniques is seemingly propitious. The monitoring of ageing of beer using enzymatic biosensors, based on cobalt phthalocyanine. These biosensors evinced a good capability to monitor the ageing of beer during storage.

Biosensors are used for the detection of pathogens i n food. Presence of Escherichia coli in vegetables is a bioindicator of faecal contamination in food. E. coli has been measured by detecting variation in pH caused by ammonia using potentiometric alternating biosensing systems.

Enzymatic biosensors are also employed in the dairy industry. A biosensor, based on a screen-printed carbon electrode, was integrated into a flow cell. Enzymes were immobilized on electrodes by engulfment in a photocrosslinkable polymer. The automated flow-based biosensor could quantify the three organophosphate pesticides in milk.

One of the popular food additives extensively used today are sweeteners, which are adversely causing undesirable diseases including dental caries, cardiovascular diseases, obesity and type-2 diabetes. A more efficacious method, which combined lipid films with electrochemical techniques as biosensors for speedy and sensitive screening of sweeteners has been explored by multi-channel biosensor, which detects the electrophysiological activities of the taste epithelium.The signals are analyzed using spatiotemporal techniques, on MATLAB, where glucose and sucrose represent natural sugars while saccharin and cyclamate comprise artificial sweeteners.

➢ In fermentation processes:

In fermentation process, saccharification was monitored by traditional Fehling's method. Since this method involves titration of reducing sugar, its outcomes were inaccurate. However, since the launch of glucose biosensor commercially in 1975, the fermentation industries have been benefited. Now the factories successfully use glucose biosensors to control production in the saccharification and fermentation workshop and utilize the bioenzymatic method to produce glucose.

➢ Biosensing technology for sustainable food safety:

The term food quality refers to the appearance, taste, smell, nutritional value, freshness, flavour, texture and chemicals. Smart monitoring of nutrients and fast screening of biological and chemical contaminants are of paramount importance, when it comes to food quality and safety.

Biosensors are being employed to perceive general toxicity and specific toxic metals, due to their capability to react with only the hazardous fractions of metal ions. Pesticides pose grave threats to the environment. The common pesticides used are organophosphates and carbamic insecticide species. Immunosensors have proved their merit as sensitive, high-speed agrifood and environmental monitoring. A similar type of biosensor is used to detect pesticides in wine and orange juice.

➢ In medical field:

In the discipline of medical science, the applications of biosensors are growing rapidly. Glucose biosensors are widely used in clinical applications for diagnosis of diabetes mellitus, Biosensors are being used pervasively in the medical field to diagnose infectious diseases. A promising biosensor technology for urinary tract infection (UTI) diagnosis along with pathogen identification and anti-microbial susceptibility is under study.

The biggest dilemma faced today is of heart failure with about one million people suffering from it so identifying end-stage heart failure patients, prone to adverse outcomes during the early phase of left ventricular assisted device implantation, is important. A novel biosensor, based on hafnium oxide (HfO_2), has been used for early stage detection of human interleukin.

A biochip for a quick and accurate detection of multiple cancer markers and neurochemical detection by diamond microneedle electrodes.

➢ Fluorescent biosensors:

Fluorescent biosensors are small scaffolds onto which one or several fluorescent probes are mounted (enzymatically, chemically or genetically) through a receptor. The receptor identifies a specific analyte or target, thereby transducing a fluorescent signal which can be readily detected and measured. The indication of arthritis, inflammatory diseases, cardiovascular and neurodegenerative diseases, viral infection, cancer and metastasis is done using these sensors.

➢ Biodefense biosensing applications:

Biosensors can be used for military purposes at times of biological attacks. The main motive of such biosensors is be to sensitively and selectively identify organisms posing threat in virtually real time called biowarfare agents (BWAs) namely, bacteria (vegetative and spores), toxins and viruses. Several attempts to device such biosensors has been done using molecular techniques which are able to recognize the chemical markers of BWAs.

CONCLUSION AND OUTLOOK

The past decade has seen great advancements in the field of biosensor along many fronts. This dynamic tool has been applied in many area of life science research, health care, environmental, food and military application. Biosensor technology has received heightened interest over the past decade, since it is a promising candidate for lower detection limit with rapid analysis time at relatively low cost. Technological advances have provided us with the tools and materials needed to construct biochip which integrated with microfluidic system, probe, sampler, detector, amplifier and logic circuitry. This biochip is a promising candidate for label free, reagentless, real time monitoring, miniaturization and low cost application. For medical application, this cost advantage will allow the development of extremely low cost, disposable biochips that can be used for in-home medical diagnostics of diseases without the need of sending samples to a laboratory for analysis which time consuming.

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