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Biosensors and their Indispensable Applications

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SUMMARY

Biosensors research is a fast growing field and the industry is now worth billions of dollars. The biosensor products have found their applications in numerous industries including food and beverages, agricultural, environmental, medical diagnostics, and pharmaceutical industries and many more. Even though numerous biosensors have been developed for detection of proteins, peptides, enzymes, and numerous other bio-molecules for diverse applications, their applications in tissue engineering have remained limited. The various types of biosensors such as enzyme-based, tissue-based, immune-sensors, DNA biosensors, thermal and piezoelectric biosensors have been deliberated here to highlight their indispensable applications in multitudinous fields. Some of the popular fields implementing the use of biosensors are food industry to keep a check on its quality and safety, to help distinguish between the natural and artificial; in the fermentation industry and in the saccharification process to detect precise glucose concentrations; in metabolic engineering to enable in vivo monitoring of cellular metabolism. Biosensors and their role in medical science including early stage detection of human interleukin-10 causing heart diseases, rapid detection of human papilloma virus, etc. are important aspects. Fluorescent biosensors play a vital role in drug discovery and in cancer. Biosensor applications are prevalent in the plant biology sector to find out the missing links required in metabolic processes. Other applications are involved in defense, clinical sector, and for marine applications. Fabrication of biosensors, its materials, transducing devices, and immobilization methods requires multidisciplinary research in chemistry, biology, and engineering. The materials used in biosensors are categorized into three groups based on their mechanisms: biocatalytic group comprising enzymes, bioaffinity group including antibodies and nucleic acids, and microbe based containing microorganisms.

INTRODUCTION

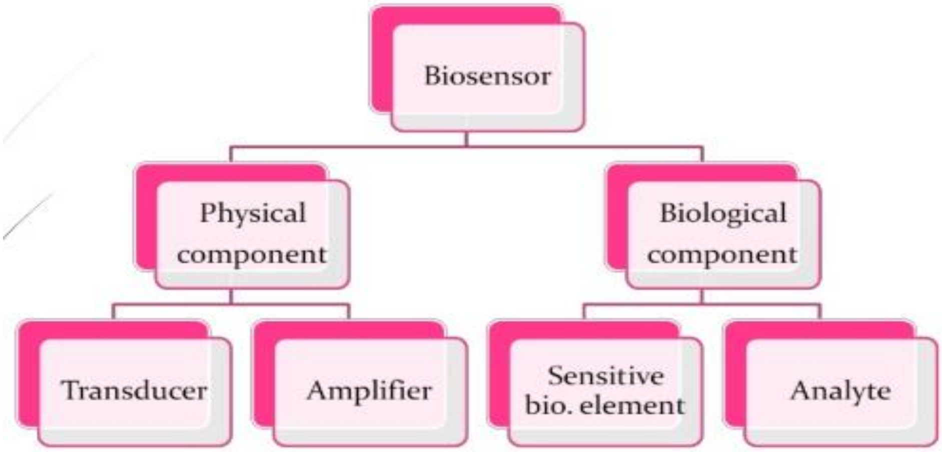
Foods are materials, raw, processed, or formulated, that are consumed orally by humans or animals for growth, health, satisfaction, pleasure and satisfying social needs. Food preservation is an action or a method of maintaining foods at a desired level of properties or nature for their maximum benefits. In general, each step of handling, processing, storage and distribution affects the characteristics of food, which may be desirable or undesirable. Thus, understanding the effects of each preservation method and handling procedure on foods is critical in food processing which lead to the safe food (Rahman 2007). Monitoring of safety and nutritional quality of food are very essential. The conventional analytical techniques for quality and safety analyses are very tedious, time consuming and require trained personal, therefore there is a need to develop quick, sensitive and reliable techniques for quick monitoring of food quality and safety. In this connection biosensor is an appropriate alternative to the conventional techniques.

Biosensor devices are emerging as one of the foremost relevant diagnostic techniques for food, clinical and environmental monitoring due to their rapidity, specificity, ease of mass fabrication, economics and field applicability. They obtain their specificity from biological binding reaction, which is derived from a range of interactions that include antigen /antibody, enzyme/ substrate / cofactor, receptor and, chemical interactions and nucleic acid hybridization in combination with a range of transducers. Present review describes several applications of biosensors for food processing and safety. Father of biosensors was Leland C. Clark**.** Biosensors are devices used to detect the presence or concentration of a biological analyte such as a bio-molecule, a biological structure or a microorganism. Biosensors consist of three parts: a component that recognizes the analyte and produces a signal, a signal transducer, and a reader device. Biosensors have extensive applications in the food and agriculture industries. The devices contain a transducer and a biological element, which may be an enzyme, antibody, microbe, or organelle. The biological element (bioelement) interacts with the analyte being tested and the biological response is converted into an electrical signal by the transducer.

Biosensors System

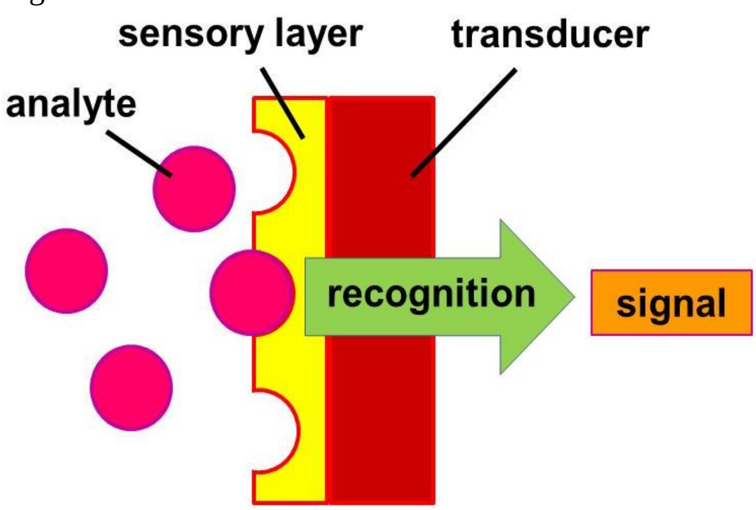
Biosensors systems are operated based on the principle of signal transduction. These components include a bio-recognition element, a biotransducer and an electronic system composed of a display, processor and amplifier. The bio-recognition element, essentially a bioreceptor, is allowed to interact with a specific analyte.

Component of Biosensors

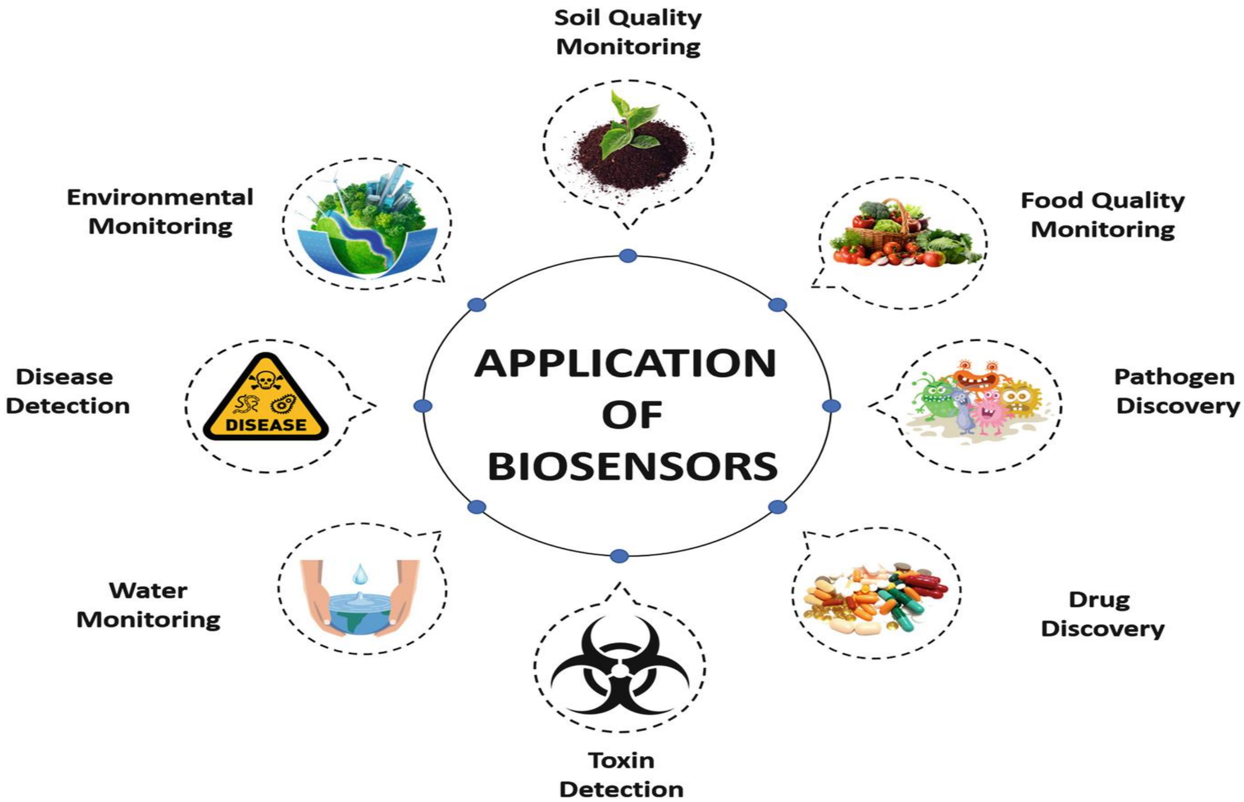


Working Principle of Biosensors

- The union of biological sensitive element and a transducer is responsible to convert the biological material into a corresponding electrical response in form of signal.
- The output of the transducer will be either current or voltage relying on the type of enzyme.
- If the output is voltage, then it is fine. But if the output is current, then this current needs to be converted into equivalent voltage (using an Op-Amp based current to voltage converter) before proceeding further.
- The output voltage signal is generally very low in amplitude and is superimposed on a high frequency noise signal.
- Thus, the signal is amplified (using an Op-Amp based amplifier) and then it is passed through a low pass RC Filter.
- Signal processing unit or a signal conditioning unit is accountable for performing this process of amplifying and filtering the signal.
- The output of the signal processing unit is termed as an analog signal. This output is equivalent to the biological quantity being measured.
- The analog signal can be exhibited directly on an LCD display but usually, this analog signal is passed to a Microcontroller, where the analog signal is converted into digital signal. This is done since it is easy to analyse, process or store a digital signal.



Applications of Biosensors



Uses of biosensors in the agricultural and food industry

- Enzyme biosensors based on the inhibition of cholinesterase enzymes are used to detect traces of organophosphates and carbonates from pesticides that may be present as poisonous and harmful residues on farm produce.
- Some microbial sensors are selective and sensitive in the detection of ammonia and methane.
- Biological oxygen demand (BOD) analyzers use bacteria such as Rhodococcus erythropolis immobilized in collagen or polyacrylamide. These devices are widely used to test the quality of waste water. BOD biosensors can analyze 2 to 20 samples every hour.
- Biosensors may be used to measure carbohydrates, alcohols, and acids in fermented foods. The devices are mainly used for quality control processes in food production. The devices, however, need to be kept sterile, frequently calibrated and require analyte dilution. Enzyme-based biosensors can be used in food quality control to measure amino acids, amides, amines, carbohydrates, heterocyclic compounds, carboxylic acids, gases, inorganic ions, cofactors, alcohols and phenols. Biosensors can also be used in the assessment and analysis of produce such as wine, beer and yoghurt.
- In food quality assessment, antibodies or immune-sensors may be used in assays to detect small molecules such as water-soluble vitamins and chemical contaminants. They may also be used to detect any pathogenic organisms present in meat, poultry, eggs, and fish.

Future Scope of Biosensors:

Cell and tissue-based biosensors consist of genetically engineered proteins that are infused into cells ex vivo or in vivo. They allow the researcher to sense levels of hormones, drugs, or toxins, continuously and noninvasively, using biophotonics or other physical principles. The scope in this regard could be of value in ageing research. Biosensors are used for marine applications for detection of eutrophication using nitrite and nitrate sensors. Various sensors based on nucleic acid hybridization detection have been developed for organism detection; “Environmental Sample Processor” is under process at the Monterey Bay Aquarium Research Institute whose goal is the automated detection of toxic algae in situ from jetty using ribosomal RNA probes is a promising development in this field. Also detection of pollutants, heavy metal and pesticides through biosensors is one of the prime goals.

Applications of nanomaterials in biosensors provide opportunities for building up a new generation of biosensor technologies. Nanomaterials improve mechanical, electrochemical, optical and magnetic properties of biosensors and are developing towards single molecule biosensors with high throughput biosensor arrays. Biological molecules possess special structures and functions, and determining how to fully use the structure and function of nanomaterials and biomolecules to fabricate single molecule multifunctional nanocomposites, nanofilms, and nanoelectrodes, is still a great challenge. The processing, characterization, interface problems, availability of high quality nanomaterials, tailoring of nanomaterials, and the mechanisms governing the behaviour of these nanoscale composites on the surface of electrodes are also great challenges for the presently existing techniques.

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