Application of Biosensors: A Review

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ABSTRACT: The various types of biosensors such as enzyme-based, tissue-based, immunosensors, 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 defence, clinical sector, and for marine applications.

KEYWORDS: Biosensors, Fermentation, Food Safety, Fluorescent, Medical.

INTRODUCTION

Biosensors are analytical instruments that transform an electrical signal into a biological reaction. Biosensors, ultimately, must be extremely accurate, irrespective of physical factors such as pH and temperature, and therefore should be reuse. Cammann introduced the name " biosensor," and IUPAC presented its concept[1].

Multidisciplinary research in chemistry, biology, and engineering is needed in the manufacture of biosensors, their components, transducing systems, and immobilisation methods.Based on their processes, the components used in biosensors are classified into three groups: the biocatalytic group comprising enzymes, the bioaffinity group involving antibodies and nucleic acids, and the microbe-based group containing microorganisms[2].

DISCUSSION

Applications of biosensors

In several sectors, such as the food industry, the medical sector, the marine sector, etc., biosensors have been introduced which provide greater stability and sensitivity compared to conventional methods[3].

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

Quality and protection, food product management, and manufacturing are an arduous dilemma in the food processing industry. Orthodox approaches that conduct chemical experiments and spectroscopy have limitations that are costly and time intensive due to human fatigue. For the food industry, strategies for food authentication and tracking with impartial and reliable mea-surement of food items are ideal, in a cost-effective way. In response to the needs for quick, real-time, selective and inexpensive strategies, the production of biosen-sors is thus apparently propitious[4].

For the identification of pathogens in food, biosensors are used. A bioindicator of faecal infection of food is the existence of Escherichia coli in vegetables. E. Coli has been assessed using potentiometric alter-natingbiosensing systems by detecting pH variance caused by ammonia (manufactured by urease-E. coli antibody conjugate). Washing vegetables like sliced carrots and peptone-water lettuce brings us the liquid step. By merging it in a sonicator, it is then isolated to disaffiliate bacterial cells from food products[5].

Sweeteners, that are negatively affecting unwanted disorders like dental caries, cardiovascular diseases, obesity and type 2 diabetes, are one of the common food additives commonly utilised today. Artificial sweeteners are known to be addictive and coax us to unwittingly consume more high-energy snacks, unintentionally inducing weight gain. Their identification and quantification are also of primary significance. Ion chromatographic techniques, which are complex and laborious, are conventional methods to differentiate the two kinds of sweeteners.

In fermentation processes

Process protection and product consistency are critical in the fermentation industry. Thus accurate control of the fermentation phase is crucial to build, refine and sustain biological reactors at full effectiveness. To indirectly assess the process conditions, biosensors can be used to track the presence of ingredients, biomass, enzymes, antibodies or by-products of the procedure. Biosensors specifically monitor the fermentation industry and, because of their basic instrumentation, formidable selectivity, cheap prices and fast automation, deliver reproducible results.Several types of commercial biosensors are now available; they are capable of detecting biochemical parameters and are commonly used in China, accounting for about 90% of its market[6].

Biosensors are also used in the retrieval of ion exchange, where variations in biochemical structure are observed. For example, a glutamate biosensor has been used to perform ion exchange retrieval experiments of a glutamate isoelectric liquor supernatant. The method of fermentation is a Byzantine process with many pivotal factors, which are mostly laborious to calculate in real time.To promote rapid optimization and to regulate biological processes, on-line tracking of vital metabolites is important. Thanks to its versatility and rapid reaction, biosensors have generated a lot of attention in online monitoring of the fermentation process in recent years.

Biosensing technology for sustainable food safety

The term food quality describes the characteristics, taste, scent, nutritious value, freshness, flavour, texture and chemicals. In terms of food quality and protection, smart nutrient control and quick screening of biological and chemical pollutants is of utmost importance. Material science, nanotechnology, electromechanical and microfluidic devices are trying to make sensing technologies appropriate for commercial use. Efforts are being made to establish control systems which ensure the quality and safety of food and, as a result, human health[7].

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 agrifoodand environmental monitoring. AChE and butyrylcholinesterase biosensors have been devised for aldi-carb, carbaryl, paraoxon, chlorpyrifosmethyl etc. Oxon utiliz-ing screen-printed electrodes was developed by Arduini and colleagues. A similar type of biosensor is used to detect pesticides in wine and orange juice. Arsenic can be measured with the help of bacteria-based bioassays.As the food quality and structure may be altered during storage, glucose control becomes indispensable. German examined the electrochemistry of glucose oxidase immobilised on a graphite rod, altered by gold nanoparticles (AuNPs), which enhanced its sensitivity[8].

In medical field

In the discipline of medical research, the implementations of biosensors are increasing increasingly. Glucose biosensors are commonly used for the diagnosis of diabetes mellitus in clinical applications that require accurate control over blood glucose levels. 85 percent of the vast world demand pays for the use of blood-glucose biosensors at home.

To detect infectious diseases, biosensors are used pervasively in the medical industry. A innovative biosensor technique is being investigated for the diagnosis of urinary tract infection (UTI) along with pathogen detection and anti-microbial susceptibility.

Today's greatest dilemma is heart disease, with over a million people who suffer from it. Immunoaffinity column assays, fluorometric and enzyme-linked immunosorbent assays are tools for the diagnosis of cardiovascular diseases. These are laborious, need trained workers, and take time. Biosensors focused on electrical calculation employ biochemical molecular recognition with a basic biomarker of importance for desired selectivity[9].

The numerous other implementations of biosensors involve: the quantitative measurement of cardiac markers in undiluted serum, the microfluidic stiffness assay for the regulation of endothelin-induced cardiac hypertrophy, the immunosensor array for the clinical immunophenotyping of acute leukaemia, the impact of oxazaborolidines on dental immobilised fructosyltransferase, the histone deacylase (HDAC) inhibitor assay,

Fluorescent biosensors

To be used in cancer and medication research, fluorescent biosensors are imaging agents. At the cellular level, they have given insights into the function and control of enzymes. FRET biosensors, based on GFP and genetically encoded, play a crucial role.

In drug discovery programmes, fluorescent biosensors are used for the detection of medicines by higher sensitivity, high content screening methods, for post-screening hit analysis and lead optimization. These are regarded as powerful methods for preclinical assessment and clinical validation of applicant medication therapeutic potential, biodistribution and pharmacokinetics.For early identification of biomarkers in molecular and clinical diagnostics, for tracking disease development and reaction to treatment/therapeutics, for intravital scanning and image driven surgery, fluorescent biosensors are used efficiently[10].

In metabolic engineering

Environmental issues and the scarcity of affordability of oil and natural gas goods are increasingly increasing the need for microbial cell factories to be built for chemical synthesis. Metabolic engineering is seen by researchers as the enabling technology for a sustainable bioeconomy. They also envisaged that by utilizing microorganisms rather than depending on oil refining or extraction from crops, a large fraction of fuels, commodity chemicals and pharmaceuticals would be made from renewable feedstocks. In order to choose the individuals bearing the required phenotype, the high potential for producing diversity often requires effective imaging techniques.Spectroscopy-based enzymatic assay analytics were the earlier approaches, but they had restricted performance. Genetically encoded biosensors that enable in vivo cell metabo-lism monitoring have been designed to overcome this challenge, providing the potential for high-throughput screening and selection using fluorescence-activated cell sorting (FACS) and cell survival, respectively.

Biosensors in plant biology

In the fields of DNA sequencing and molecular imaging, innovative new developments have contributed to advances in plant science. Traditional mass spectroscopy techniques for calculating insights into cellular and subcellular localization and measuring ion and metabolite levels had unparalleled sensitivity, but crucial knowledge on the position and dynamics of substrates, receptors and transporters of enzymes was lacking. However, utilizing biosensors, this data can effectively be tapped successfully.We need to formulate strategies to imagine the real mechanism in order to calculate a complex process under physiological circumstances, such as transforming one metabolite into another or causing signalling events. Sensors which react dynamically can do this visualisation[11].

CONCLUSION

Biosensors based on cells and tissues consist of genetically modified proteins that are injected ex vivo or in vivo into cells. They enable the investigator, utilizing biophotonics or other physical concepts, to sense levels of hormones, medications, or toxins, continuously and noninvasively. The spectrum may be of use in ageing studies in this respect.

For marine applications, biosensors are used to detect eutrophication through nitrite and nitrate sensors. For organism identification, different technologies based on nucleic acid hybridization identification have been developed;" Environmental Sample Processor " has been under progress at the Monterey Bay Aquarium Research Institute, whose objective is to automated the identification of toxic algae in situ from moorings using ribosomal RNA probes. One of the main targets is the identification of toxins, heavy metals and pesticides by biosensors.

Nanomaterial implementations in biosensors create opportunities for a new generation of biosensor technology to be developed. Nanomaterials strengthen the mechanical, electro-chemical, magnetic and optical properties of biosensors and evolve into high-throughput biosensor arrays of single molecule biosensors. Biological molecules have complex structures and functions, and it is still a big challenge to decide how to completely exploit the function and structure of nanomaterials and biomolecules to generate multifunctional single-molecule nanocomposites, nanofilms, and nanoelectrodes.

Production, classification, interface issues, high-quality nanomaterial availability, nanomaterial modification and the processes controlling the behaviour of these nanoscale composites on the electrode surface are all significant issues for conventional technologies. There are several significant impediments as how to increase the signal to noise level, how to improve signaling pathways and enhancement.

Future studies should concentrate on explaining the principle of activity on the electrode surface or nanofilms among nanomaterials and biomolecules while using potential applications to generate new generations of biosensors. Nonetheless, nanomaterial-based biosensors display highly appealing characteristics that will be commonly used in the near future in medical diagnosis, nutritional analysis, process management, and environmental management.

REFERENCES

[1] P. Mehrotra, "Biosensors and their applications - A review," *Journal of Oral Biology and Craniofacial Research*. 2016, doi: 10.1016/j.jobcr.2015.12.002.

[2] K. M. Polizzi, "Biosensors," in *Comprehensive Biotechnology*, 2019.

[3] C. M. Pandey and B. D. Malhotra, *Biosensors: Fundamentals and applications*. 2019.

[4] M. S. Thakur and K. V. Ragavan, "Biosensors in food processing," *Journal of Food Science and Technology*. 2013, doi: 10.1007/s13197-012-0783-z.

[5] P. Poltronieri, V. Mezzolla, E. Primiceri, and G. Maruccio, "Biosensors for the Detection of Food Pathogens," *Foods*, 2014, doi: 10.3390/foods3030511.

[6] J. Shi, D. Feng, and Y. Li, "Biosensors in Fermentation Applications," in *Fermentation Processes*, 2017.

[7] S. Neethirajan, V. Ragavan, X. Weng, and R. Chand, "Biosensors for sustainable food engineering: Challenges and perspectives," *Biosensors*. 2018, doi: 10.3390/bios8010023.

[8] V. Scognamiglio, F. Arduini, G. Palleschi, and G. Rea, "Biosensing technology for sustainable food safety," *TrAC - Trends in Analytical Chemistry*. 2014, doi: 10.1016/j.trac.2014.07.007.

[9] C. Rivet, H. Lee, A. Hirsch, S. Hamilton, and H. Lu, "Microfluidics for medical diagnostics and biosensors," *Chem. Eng. Sci.*, 2011, doi: 10.1016/j.ces.2010.08.015.

[10] S. B. VanEngelenburg and A. E. Palmer, "Fluorescent biosensors of protein function," *Current Opinion in Chemical Biology*. 2008, doi: 10.1016/j.cbpa.2008.01.020.

[11] A. Sadanandom and R. M. Napier, "Biosensors in plants," *Current Opinion in Plant Biology*. 2010, doi: 10.1016/j.pbi.2010.08.010.

Prachi Dewal, Gagandeep Singh Narula and Vishal Jain, "Detection and Prevention of Black Hole Attacks in Cluster based Wireless Sensor Networks", 10th INDIACom; INDIACom-2016, 3rd 2016 International Conference on "Computing for Sustainable Global Development", 16th – 18th March, 2016 having ISBN No. 978-9-3805-4421-2, page no. 3399 to 3403.

• Ishleen Kaur, Gagandeep Singh Narula, Vishal Jain, "Differential Analysis of Token Metric and Object Oriented Metrics for Fault Prediction", International Journal of Information Technology (BJIT), Vol. 9, No. 1, Issue 17, March, 2017, page no. 93-100 having ISSN No. 2511-2104.

• Basant Ali Sayed Alia, Abeer Badr El Din Ahmedb, Alaa El Din Muhammad,El Ghazalic and Vishal Jain, "Incremental Learning Approach for Enhancing the Performance of Multi-Layer Perceptron for Determining the Stock Trend", International Journal of Sciences: Basic and Applied Research (IJSBAR), Jordan, page no. 15 to 23, having ISSN 2307-4531.• RS Venkatesh, PK Reejeesh, S Balamurugan, S Charanyaa, "Further More Investigations on Evolution of Approaches for Cloud Security", International Journal of Innovative Research in Computer and Communication Engineering , Vol. 3, Issue 1, January 2015

- K Deepika, N Naveen Prasad, S Balamurugan, S Charanyaa, "Survey on Security on Cloud Computing by Trusted Computer Strategy", International Journal of Innovative Research in Computer and Communication Engineering, 2015

- P Durga, S Jeevitha, A Poomalai, M Sowmiya, S Balamurugan, "Aspect Oriented Strategy to model the Examination Management Systems", International Journal of Innovative Research in Science, Engineering and Technology , Vol. 4, Issue 2, February 2015