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Biosensors: A New Era in Disease Diagnosis and Industrial Biotechnology

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Review Article

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ABSTRACT

Biosensor concept and its widespread applications have drawn global research attention. They have been successfully utilized in many ways for the betterment of quality life. Their applications have been spreading in each field starting from simple glucose test to nuclear tests. Here in this present study few applications of biosensors in the field of Disease Diagnosis & Industrial biotechnology have been reviewed. The future of these biosensors is also mentioned at the end considering the recent trends and the literature available on publication web.

INTRODUCTION

Biosensor

Primarily, a sensor can be defined as a device which is capable to detect or measures a physical property. It may also records or indicates and may respond to it otherwise. Microphone for sound, Thermometer, thermocouple and pyrometer for temperature, Hydrometer for density, Barometer for pressure, Breath analyser for chemical, and anemometer for wind speed are few popular sensors to exemplify. The sensor which uses a biological component to detect the analyte to detection of various compounds with more specificity and sensitivity will now be called as a biosensor [1-3]. They contribute to the advancement of number of fields including biotechnology, disease diagnosis, and health care to improve quality of life [4], industrial applications [5], environment and food industry. They are being used as pivotal elements in forensic science [6]. They are popularly being used in 1) Industry for process monitoring and control, particularly food and drink; 2) Medicine for diagnostics, metabolites, hormones; 3) Military for battlefield monitoring of poison gases, nerve agents & people; 4) Domestic for home monitoring of non-acute conditions [7].

Biosensor is an emerging tool which combines both the principles of biology and electronics. In other words, this is to combine the advantages of sensor technology [8] and the life sciences. The success of developing biosensors may depend of efficient assembly, devices, and architectures. It also requires ones understanding towards Biology, Chemistry, Material Science, Electronics and Physics [6].

Biosensors comprise of a bio component that traces out molecules (analyte), a transducer and an electronic processor [9]. The reaction between the bio component and the analyte leads to a physicochemical change, which then converts to electrical signal by transducer. Biological component might be any tissue, microorganisms, organelles, cell receptors, chemicals, antibodies, nucleic acids, and so forth. A biologically derived material or biomimetic part that associates (ties or perceives) the analyte under study [9]. Their capacity is to distinguish the sign from environment through some biochemical reactions. Whereas transducer converts the bio chemical signal to electric signal and then is processed by electronic processor. Conventional methods do suit for the analysis however they lack sensitivity and specificity [10]. Biosensors overcome these limitations [11] and could provide reliable data with more specificity and even at low sensitivities.

APPLICATIONS OF BIOSENSORS

Disease Diagnosis

Cancer diagnosis

Cancer is the alarming cause for the medical deaths around the globe. Early diagnosis is crucial for the successful treatment and for the better chances [12,13]. Tumour development is linked with gene and protein changes generally come about because of the mutations and these changes can be used as biomarkers for the diagnosis. Cancer biomarkers are possibly a standout amongst the most significant tools for early cancer detection. Biosensors have been developed with an end goal to enhance the analysis and treatment of different cancers. Aptamers, ssDNA, dsDNA, antibodies and particular antigens (p53 antigen) can be utilized as the bio-component in these biosensors. Aptamer based biosensors combined with gold nanoparticles has been developed. The principle of detection is based on absorption changes. Nanoparticles are met up on the tumor cell when particular aptamer is bound to its target cell; upon which colour and absorption will change for the sample which in turn enables us to detect cancers.

This procedure can also be utilized for the finding of non-little cell lung disease (NSCLC). In another study, Kwon et al. joined the aptamers with directing polymer tubes in a biosensor for the identification of a specialist in charge of angiogenesis amid disease named as Vascular Epidermal Growth Factor (VEGF) furthermore uncovered that tubes with littler size demonstrates the high level of sensitivity during detection [14,15].

Alzheimer disease

Biosensors have additionally spread their way into the recognition of neurogenerative issue [16,17].

Diabetes mellitus

Diabetes mellitus is caused due to abnormal levels of blood glucose [18]. Amperometric enzyme electrode, based on glucose oxidase (GOx), is used in developing easy-to-use glucose testing. It can be used for monitoring glucose level on continuous mode. Since Clark and Lyons proposed in 1962 the underlying idea of glucose chemical terminals [7,9,19], we have seen colossal exertion coordinated toward the improvement of solid gadgets for diabetes control. Distinctive methodologies have been investigated in the operation of glucose enzyme electrodes [20-25].

Cardiovascular maladies

Cardiovascular infection is another generally happening sickness with developing frequencies and consequently identification of the cardiovascular biomarkers is essential in clinical viewpoints [26-32]. Research has found on the schemes required to develop an RNA based aptasensor. The principle is the charge dissemination marvel displayed by an aptamer-CRP complex on the GID capacitor under electric field. It can recognize C-receptive protein (CRP), the most widely recognized biomarker for CVD with a location farthest point of 100–500 pg/ml.

Recently, little and effectively compact aptamer based electrochemical biosensor was produced for the identification of vasopressin, a biomarker for traumatic wounds [33-35].

Systemic lupus erythematosus

SLE is an auto-invulnerable confusion which affects diverse parts of human body. The patients experiencing SLE build up a wide assortment of serologic signs. SPR based biosensor chip was created to recognize pathogenic dsDNA in the event of immune system issue SLE.

Tuberculosis

Tuberculosis, one of the world's dangerous illness and is brought on by pathogenic bacterium *M. tuberculosis*. Early diagnosis of the disease may be profited in clinical point of view. Numerous assortments of Biosensors (DNA/RNA/PNA) were created for Tuberculosis detection utilizing the outfits of Optical, Piezoelectric, electro-chemical principles.

Hepatitis

Hepatitis is an infectious disease caused by different strains of hepatitis virus (HAV- HGV). Gold nanoparticle based DNA biosensor has also been executed to screen hepatitis B virus DNA with a detection cut-off of 15 pmol/L. In another study, non-auxiliary viral protein 3 (NS3) has been recognized by biotinylated RNA test based biosensor with an identification limit of 500 pg/ml [36-38].

Diarrhoea

Caused by pathogenic microbes such as *E. coli* O157:H7, *S. typhimurium* etc. Aptamer based biosensor was developed for the detection of these microscopic organisms utilizing unmodified gold nanoparticles by colorimetric examine [39].

Cholera

Caused by *Vibrio cholerae*. A DNA biosensor was created for the discovery of PCR amplicons of *Vibrio cholera* [40].

Salmonellosis

It is a globally spread disease caused by *Salmonella* sp. Determination of the invA gene of *Salmonella* is crucial and is done by SPR detection method [41,42]. DNA biosensors have found its application in the diagnosis.

Dengue

Dengue fever is an infectious disease and is vector-borne. It is mainly caused by Dengue viruses. Nucleic acid based biosensors and now being used to detect this fever because of the benefits of high surface area [42]. Studies reveal that there has been a non-porous alumina layered electrochemical DNA biosensor is developed for the detections of cDNA arrangement. Recently, identification of 31-mer oligonucleotide grouping of Dengue infection has been identified by the use of DNA sensing technology [43,44].

BIOSENSORS: INDUSTRIAL BIOTECHNOLOGY

Biosensors and Foodborne Bacteria Monitoring

Microbiological safety is the primary concern of most food manufacturing units and has to be monitored on regular basis. Biosensors would be preferred in such cases to avoid any safety inspection lag. These biosensors would detect the specific molecules connected with bacterial action [45,46].

Milk Purification

Lead (Pb II) has drawn the attention of the world health researchers because of its expanding pollution level and the adorable consequences. Hence continuous monitoring is required in all the means in which the possibility of lead to enter in human body prevails [47]. Various methodologies have been utilized by researchers to create biosensor for lead detection in the milk. Durrieu and Tran–Minh reported restraint of soluble phosphatase within the sight of lead as a bioassay standard for the advancement of an optical algal biosensor [48-54]. Kuswandi [54] utilized fiber optic innovation, to build up an optical Pb (II) biosensor. Urease movement based optical biosensor was produced by Tsai [55,56]. Later a multi examination 50 spot cluster based optical biosensor was produced by Tsai and Doong [56], the sensor depended on fundamental rule of hindrance of urease and acetylcholinesterase by overwhelming metals. Both the chemicals were co – immobilized with FITC dextran in sol – gel grid for multianalyte discovery. The biosensor showed identification range from 10 nM to 100 nM for Cd (II), Hg (II) and Cu (II), yet no reaction was seen against Pb (II). Haron and Ray built up a biosensor taking into account hindrance of urease and acetyl cholinesterase by Pb (II) and a recognition point of confinement of 4.83 nM was accomplished utilizing cyclotetrachromotropylene (CTCT) as a marker [57-67].

The living period of bacterial spores rotates around two stages i.e. torpid state and metabolically dynamic vegetative state. This change starting with one stage then onto the next stage is finished only when favourable conditions prevails in its near environment and presence or absence microbial or non-microbial contaminants. So this trait can be focused to sense the presence of contaminants in milk and henceforth create spore based biosensor frameworks. Various spore based detecting framework have been created to identify aflatoxin, anti-toxins and microbial pathogens in milk. These biosensing frameworks are better over existing strategies as far as better sensitivity, ease and help in fast examination of milk and milk products. The spore based biosensor is a novel system to guarantee safe and healthy milk to each consumer.

OTHER APPLICATIONS

1) Environmental and military; 2) Dip stick test; 3) Agri and Aquaculture; 4) Biosensors has found their way even in detection of viral, fungal and bacterial diseases of plants. Freshness of the food items can also be found.

RECENT TRENDS IN BIOSENSOR APPLICATIONS

The usage of biosensors in the field of environmental monitoring is rapidly increasing in recent times. After the establishment of Kyoto Protocol, nations started focusing on measuring the pollution control that may start diminishing environmental damage. Biosensors then gained huge popularity as a device to perform such detections. A standout amongst the most investigated strategy for measuring contamination is the Biochemical Oxygen Demand (BOD5) technique, which measures the organic oxygen interest of wastewaters amid 5 days at

20°C. An expansion in these type of biosensors is increasing in recent times because of their capacity to enhance identification quantification of chemical and biological agents [68-71]. Recently the focus has been shifted in developing genetically encoded FRET Biosensors as they are capable to analyse the signalling pathways both in living cells and organisms [72-76].

Carbon nanotube based biosensors are now been able to recognize various foodborne pathogens such as E. coli and *S. aureus* with an examine time of 1 min. *S. aureus* and *S. typhimurium* are additionally recognized from food tests by a double excitation detecting strategy [16,77]. Biosensors assumed an essential part in diagnosing UTIs and identifying the related uropathogen, which helped in endorsing a suitable antibiotic treatment [16,78].

Graphene (GE) is a new and evolving approach of carbon material as a biosensor as it is advantageous in quick electron transportation and in low crude material costs [79-83]. It is primarily is with single layer of carbon particles in a two-dimensional grid, the combination of GE with Nobel metal nanoparticles had demonstrated the promising applications in electrochemical biosensors. Looking at the advantageous trend Zhang et al. [79] have developed a cholesterol biosensor by the fusion of Chox with the aid of chitosan (CS). They have also determined the free cholesterol in human serum successfully [84,85].

BIOSENSORS: THE FUTURE

Smart-farming with Biosensor Equipped Stock

Smart farming enables farmers' to access the full information and about their stock in time to time. Real-time physiological and behavioural traits from animals will give markers that empower quick administration activities that avoid stock and subsequently profit losses [86]. Utilizing Biosensors to enhance decision supportive networks avoids stock losses and can help the general sustainability and productivity [87,88].

E-health

Research on cell phone based nanobiosensor models, for example, Lateral flow assays (LFA), flow cytometry, and optical recognition has been of global research interest. Case of few marketed cell phone based models are iHealth, AliveCor, GENTAG, Mobile Assay, and CellScope and so on [89-92].

Lab-on-a- chip (LOAC)

The idea was started from microfluidics related thoughts. Recent trend confirm us that it can be fall into nanofluidic field now in light of reducing the size of devices and response volume of fluidics. Fundamentally, LOAC is a flow channels either in glass or silicon substrates and will be incorporated with stream infusion/pumping framework considering liquid transport inside the chip and sample handling for detection. In the view of biosensor innovation, LOAC is the finished framework which can do a complete bio-sample handling and investigation framework on a chip scale [93-100]. A bio-sample with a little measure of liquid is acquainted with the chip, then blended with reagents and supports, responded to frame items took after by assembly of it to a division unit for investigation, coordinated on the same wafer. LOAC will significantly affect the diagnostics business, both regarding concentrated lab examination and the point of care testing [16].

CONCLUSION

Biosensors have grabbed in the business sector through different applications, for example, In vivo observing, blood checking, disease diagnosis, water quality and so on. Biosensor comprises of bio-material that is delicate and sensitive. The factors like durability and solidity can grow the business sector and can make significant additions in the exploration and creation of bio sensors. The future is very promising for the development of biosensors and their applications.

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