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Biosensors in Medicine

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ABSTRACT

Biosensors devices have attracted the attention of many researchers across the world. They have the capability to solve a large number of analytical problems and challenges. They are future ubiquitous devices for disease diagnosis, monitoring, treatment and health management. 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. In this research paper we have been highlighted applications of biosensors in medicinal field.

Keywords : Biosensors, Biosensors In Medicine, Environmental Monitoring, Genetic Enginnering.

I. INTRODUCTION

Biosensors have shown to be very helpful in our daily life and to play a relevant role in agriculture, food safety, homeland security, bioprocessing, environmental and industrial monitoring. However, biosensing in medicine is the most promising application of the field, since there is a need for new and improved devices with sensitivity, specificity, reliability and biocompatibility for the diagnosis, monitoring and treatment of several health conditions. Additionally, to the troubleshooting, real-time monitoring and management of health problems, biosensors must also be able to simultaneously detect multiple analytes or stimulus, within biological fluids, outside and inside the body (Perumal and Hashim 2014). The demand for constant monitoring of vital signs aims to solve the issue related to the conventional need of hospitalization and supervision of the patient. Therefore, several studies have been made in researching and developing skin-integrated and implantable medical devices. In these devices, the most often monitored vital signs are heart electrical signals, blood pressure, pulse rate, blood glucose level, and respiration efficacy (Lee 2015). Advances in this field have provided freer patient motion and uninterrupted diagnostic data streams for medical monitoring (Rebelo et al. 2019).

In a biomedical context, biosensors need specific requirements, such as biocompatibility (sometimes, biodegradability and/or bioresorbability), miniaturization and reliability. All this progress in biosensors field has opened new routes to improve the medical care, diagnostic systems and the patient's commodity. The aim of this review is to give a brief overview in the biosensors field and applications of biosensors in medicine.

II. BIOSENSORS IN MEDICINE

Biosensors, as a fast-growing field by virtue of their ability to drastically help a number of analytical challenges and problems, have found applications in distinct areas, like agriculture and food safety, environmental monitoring, biotechnology, genetic engineering, pharmacology, defence, homeland security, industry, and essentially, in medicine and health care. In agricultural industry, biosensors are used for certain cases such as enzymes biosensors, to detect organophosphates and carbamates from pesticides, microbial biosensors for measurement of methane and ammonia, and bacteria-based biosensors for wastewater quality control. Regarding the food industry, biosensors are being used to measure amino acids, carbohydrates, inorganic ions, alcohols, acids, etc.(Hasanet al.,2014); Kirsch (2013); Mohanty and Koucianos 2006). Despite all the mentioned application areas, the most popular and with enormous potential is the application in medicine and biomedical diagnosis. This potential is driven by the need to solve medical and health problems including diabetes, cancer, chronic diseases such as heart disease, respiratory diseases, stroke, obesity, and so many others. Hence, measurements that are being established in health care are related to blood metabolites like glucose, lactate, and urea, and also to cancer biomarkers, folic acid, biotin, vitamin B12 and pantothenic acid. The first introduction of a biosensor in medicine was in 1962, with the development of an amperometric enzyme electrode (platinum) for a glucose sensor by Leland C. Clark and Champ Lyons. These platinum electrodes detected oxygen as a result of the change on the enzymatic activity of the enzyme glucose oxidase which was entrapped with a dialysis membrane at the electrodes, depending on the surrounding concentration of oxygen(Clark and Lyons 1962); (Mohanty and Koucianos 2006).Since then, glucose biosensors have so far been the most frequent, and many other biosensors have been developed for medicine, regarding improvements in the sensitivity, selectivity, and multiplexing capacity. Lately, there is a growing interest in the application of biosensors in tissue engineering, notably in microfluidic tissue engineering models, since they can help sense specific biological molecules within the miniaturized tissue constructs in real-time, by means of ultrasensitive optical, electrochemical, or acoustic systems (Hasan et al. 2014); (Systems et al.2019). In medical and biomedical fields, biosensors must be very accurate, reliable, and should exhibit a high long-term stability with very little drift, and be resistant to the application of mechanical force, such as the ones generated by pulsatile blood flow (Kim 2011); (Bandodkar, Jia, and Wang2015). Furthermore, implantable or wearable medical devices also need to be small, or otherwise they can be uncomfortable and bulky for the patient, especially when employed in confined volume areas, like blood vessels, lungs or the brain. In addition, biosensors should not affect the measurement environment or patient's well-being (Poeggel 2015). Although more challenging in terms of technology advances, both implantable and wearable devices, have in common the fact that they allow the collection of vital signals information (such as heart rate, respiration rate, skin temperature) and consequently, the monitoring of patients' health over long periods of time.

III. APPLICATIONS OF BIOSENSORS 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, which requires precise control over blood-glucose levels (Scognamiglio, Pezzotti G. and Pezzotti I.2010). Blood-glucose biosensors usage at home accounts for 85% of the gigantic world market (Rea, Polticelli and Antonacci 2009).

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.

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 (IL)-10 (Lee, Zine and Baraket 2012). Interaction between recombinant human IL-10 with corresponding monoclonal antibody is studied for early cytokine detection after device implantation. Fluorescence patterns and electromechanical impedance spectroscopy characterize the interaction between the antibody–antigen and bio-recognition of the protein is achieved by fluorescence pattern. Chen et al. applied HfO_2 as a greatly sensitive bio-field-effect transistor (Chen, Liu, Kaneko and McIntyre 2010). HfO_2 biosensor has been functionalized for antibody deposition with detection of a human antigen by electrochemical impedance spectroscopy.

The biggest dilemma faced today is of heart failure with about one million people suffering from it. Techniques for detection of cardiovascular diseases include immunoaffinity column assay, fluorometric, and enzyme-linked immunosorbent assay (Ooi et al. 2006); Caruso, Trunfio and Milazzo 2010) ; Caruso, Verde and Cabiati 2012) ; Watson, Ledwidge and Phelan 2011); Maurer, Burri and de Marchi 2010). These are laborious, require qualified personnel and are time consuming. Biosensors established on electric measurement employ biochemical molecular recognition for desired selectivity with a particular biomarker of interest.

The various other biosensors applications include: quantitative measurement of cardiac markers in undiluted serum, microfluidic impedance assay for controlling endothelin-induced cardiac hypertrophy, immunosensor array for clinical immunophenotyping of acute leukemias, effect of oxazaborolidines on immobilized fructosyltransferase in dental diseases; histone deacylase (HDAC) inhibitor assay from resonance energy transfer, biochip for a quick and accurate detection of multiple cancer markers and neurochemical detection by diamond microneedle electrodes.

IV. CONCLUSION

Biosensors have been miniaturised extensively in the recent years. Keeping in line with such developments , microbial cells with high enzyme activities may be required. This is essential especially when microbial cells are used as substitutes to enzyme based sensors. Microorganisms, due to their low cost, long lifetime and wide range of suitable pH and temperature, have been widely employed as the biosensing element in the construction of biosensors.

V. FUTURE SCOPE

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.

VI. CONFLICTS OF INTEREST

The author has none to declare.

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