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Editorial

Biosensors and their applications in healthcare

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ABSTRACT

Biosensor is a bio-analytical integrated device that uses a biological detection system to target molecules or macromolecules. Biosensors can provide specific quantitative and semi quantitative analytical information using biological recognition by coupling to a physiochemical transducer which converts this recognition into a detectable output signal. The characteristic features of a biosensor are linearity, sensitivity, selectivity and response time. Biosensors have potential applications beginning with medical, pharma, environmental, biodefence and food & beverage and have now extensive applications in health care. Biosensors are involved in molecular diagnosis, crime detection, drug development, food analysis, industrial process control, environmental field monitoring, detection systems in biological warfare agents and in manufacturing of pharmaceuticals and organ replacement. Biosensors have firmly established their applications in health care in the measurement of blood metabolites such as glucose, lactate, urea and creatinine, diabetes therapy, cardiovascular disease biomarkers and cancer biomarkers. This review mainly focuses on the recent advances and applications of biosensors in health care.

Key words: Biosensors; Healthcare; Metabolites

Biosensors are defined as transducers which integrate biological component as a significant functional element. Biosensors are chemical sensing devices which consist of three main components: biorecognition element, the transducer and signal display. The analyte interacts with the biorecognition element. This interaction is converted into a quantifiable signal by the transducer. The display shows the signal generated by the interaction of the analyte. Biosensors have the ability to provide an analytically powerful and inexpensive alternative to conventional tools by enabling the identification of target substances[1,2]. Biosensors are powerful and reliable tools for analysis of biomolecular interactions and are an essential prerequisite for health care industry. They are used in the analysis of biochemical, clinical and environmental studies. Biosensor devices are significant in health care applications due to its small size, specificity, faster response and its cost. It also provides rapid and accurate results[3]. Thus it has significant applications in the measurements of metabolites, blood cations and gases. Over the last decade, biosensors have attracted a lot of attention worldwide and lot of research is focused on the development of novel biosensors[4].

There are three so-called biosensor generations:

i) First generation biosensors are those where the normal product of the reaction diffuses to the transducer and causes the electrical response.
ii) Second generation biosensors involves specific mediators between the reaction and the transducer in order to generate improved response.
iii) Third generation biosensors are self-contained nature of the sensor where the reaction causes the response and no product is directly involved.

Biosensors have lot of applications in clinical diagnosis, food industry, biotechnology, genetic engineering and environmental aspects. In this review paper, we have highlighted the recent advances and applications of biosensors in health care which accelerates the growth of clinical diagnostics industry[5].

Biosensors in clinical diagnostics: Biosensors are point-of care devices (POC) which analyse clinical samples and involve specific markers for the specificity and efficiency[6]. Diabetes, disease hormonal disorder altering glucose utilization and transport, results in abnormal blood glucose levels. Biosensors such as Refloux and Ektachem are commercially available and are useful in measuring blood glucose levels. These devises are found to be efficient when compared with the measurement of glucose in whole blood samples. Enzyme thermistors (ET) are sensitive devices which involve the principle of measuring heat using thermometric devices. ET is used for monitoring proteins eluting from the chromatographic column. Recently, diagnostic devices were also involved in determining lipid profile. LDL, HDL and total cholesterol are measured using ET[7,8]. ET is also employed in the measurement and development of retinol biosensor using retinol binding protein as specific receptor for retinol (vitamin A). Multi-array sensors are used for cancer diagnosis and are known to be efficient in multiplexing. Molecular recognition entities like antibody biosensors provide high range of specificity and sensitivity and are used for clinical diagnosis. Monoclonal and polyclonal antibodies are employed in cancer treatment and diagnosis by targeting cancer cells and tumors inside the body. Current advances in proteomics and genomics have elucidated new biomarkers like, protein micro-arrays, serological analysis of recombinant DNA expression libraries (SEREX), serological proteome analysis (SERPA), which is involved in cancer diagnosis and prognosis. Molecular tools like PCR, RT-PCR, DNA sequencing and southern blotting are involved in clinical applications. ELISA tests, dipsticks and assays are commercially available for diagnostic purposes. Peptide ligands have been used as specific target analytes in clinical diagnosis. Biomarkers like HER2/neureceptor, ErbB-2 and ICAM-1 are used in cancer diagnosis. DU145 biomarker is used in identifying prostate cancer[9]. Cardiac troponin is one of the commonly used biomarker for myocardial disease. CRP is found to be the only marker of inflammation which predicts the risk of heart attack.

Biosensors in food industry: Immunoassays are used for the detection of protein in genetically modified (GM) foods. It is also involved in the analysis of GM foods in plant tissues, raw agricultural supplies and food ingredients[10]. DNA biosensors like PCR have been developed for the detection of genetic abnormalities and infectious diseases. Quantitative PCR techniques are found to be extremely sensitive automated detection system due to their speed and cost effectiveness. GeneScan Europe test kits have been developed for the detection of GM components in animal and human food by DNA analysis using PCR techniques. DNA chips are used for the detection of GM foods and in the detection of microorganisms. Biosensing DNA probes are used for the detection of food-borne pathogens such as *E.coli, S.aureus, Salmonella*. Electronic noses are artificial receptors in sensor array and are emerging biosensors in food analysis. These are also used in medical and environmental diagnosis[11].

Biosensors in environmental sector:

Biomonitoring involves the measurement and assessment of metabolites in tissues and other organs. The evaluation of biological monitoring methods is done in order to assess the risk efficiency against the various kinds of toxins. The use of genetic engineering to create organisms is specifically designed for bio remediation and has found to have great potential. *Deinococcus radiodurans* , the radio-resistant organism has been modified to consume and digest toluene and ionic mercury from highly radioactive nuclear waste[12]. Some of the significant biosensors used in environmental pollution monitoring are:

a) Gas biosensors- For detection of gases such as sulphur dioxide, methane, carbon dioxide etc, microbial biosensors have been developed. Thiobacillus-based biosensors are used for the detection of SO_2 pollutant and methane (CH_4) by immobilized *Methalomonas.* Specific strain of *Pseudomonas* is used to monitor carbon dioxde levels.
b) Immunoassay biosensors- Immunoelectrodes are used as biosensors for detecting low concentrations of pollutants. Pesticide specific antibodies have the ability to detect even low concentrations of triazines, malathion and carbamates, via immunoassay methods[13].
c) BOD biosensor- Biological oxygen demand (BOD) is a test which is widely used to detect the levels of organic pollution. BOD biosensor using the yeast *Trichosporon cutaneum* involving oxygen probe consumes less time of about 15 minutes only, to detect organic pollution when compared to the normal test which takes about 5 days for assessment[14].
d) Miscellaneous biosensors- Cynobacterium and Synechococcus (graphite electrodes) have been used to measure the degree of electron transport inhibition during photosynthesis, by certain pollutants e.g. herbicides. Phenol oxidase enzyme is used as a biosensor to detect phenol. The enzyme is obtained from potatoes and mushrooms. Polychlorinated biphenyls (PCBs) and chlorinated hydrocarbons and other organic compounds are also detected using biosensors[15].

Biosensors in cosmetic applications:

Thermometric sensing techniques are also used in measuring the fluoride content in cosmetic samples. Microbial lipases have gained much attention due to their rapid progress in the field of enzyme technology. Lipases are biocatalysts and are used as biosensors in cosmetics and perfumery[16].

CONCLUSION AND FUTURE PROSPECTS

Application of biosensors in medical diagnosis is extremely successful and has widened to agriculture, environmental and food industries. Enormous research studies are being undertaken by research and development companies and diagnostic centers to develop simple, sensitive and cost effective biosensor technologies.

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