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Emerging trends in biosensor technology for healthcare and environmental monitoring

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Abstract- A strong and advanced analytical tool containing biological sensing elements, a "biosensor" has several uses in drug development, diagnosis, biomedicine, food safety and processing, environmental monitoring, defense, and security. Because of its potential applications in clinical treatment, pharmacy, the biomedical industry, and healthcare, biosensors research is gaining a lot of attention. The use of biosensors has become essential in the areas of environmental monitoring, drug development, biomedicine, food safety regulations, defense, and security. There are many possible uses for a variety of biosensors, including those made of microorganisms, polymers, and nanomaterials. In order to create biosensors with a wide range of potential applications, it is crucial to incorporate varied design methodologies. Thus, this review presents a summary of the various kinds of biosensors and their uses in different fields.

Key words: Biosensor, Pharmacy, Heath care, Defense, Environment.

INTRODUCTION

The first biosensor was developed by Clark and Lyons (1962)[1] using an immobilised glucose oxidase electrode to measure the glucose in biological samples by electrochemically detecting oxygen or hydrogen peroxide.[2] Since then, amazing advancements in technology and biosensor applications have been made using innovative techniques in electrochemistry, nanotechnology, and bioelectronics.[2]

The bio-recognition system of a biosensor can be used for classification. Nucleic acids/complementary sequences, antibody/antigen, and enzyme/substrate are the primary biological materials utilised in biosensor technology. Furthermore, complete animal or plant cells, tissue sections, and microbes can all be included in the biosensing system. A different strategy that makes use of artificial biomimetic recognition systems is provided by recent advancements and innovations in the field of molecular imprinting. Any analyte molecule can be synthesised using molecular imprinted polymers, which have the same affinities and specifities as biological recognition elements for the binding target molecules.[3]

Biosensors are successfully used for managing human health, identifying diseases, preventing them, rehabilitating patients, and monitoring their health.[4] Biosensors are used by the automotive sector, DNA, intelligent textiles, and a plethora of other industries on various substrates. Because biosensors have so many uses,

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it is crucial to understand their potential, uses, and technological advancements. The enormous potential and technologies of biosensors in several sectors are discussed in this paper.

Electrochemical biosensors

Discovery of electrochemical biosensors is the traditional glucometer, which was discovered by Clark and Lyons (1962)[1] by using glucose oxidase-based biosensors. Hospitals and diagnostic centers frequently use glucose biosensors because they are essential to diabetic patients' for blood glucose monitoring.[5] Another application of the electrochemical biosensor is to measure the concentration of reactive oxygen species and antioxidants in physiological systems. The identification of uric acid as the principal byproduct of body fluid purine metabolism is a major application in this field.[6] This identification serves as a diagnostic tool for a number of clinical abnormalities or disorders.

Optical or Visual biosensors

The creation of ultra-sensitive, fast, and straightforward biosensors is necessary for environmental or biological applications. This might be achievable with immobilizers made of glass, silica, quartz, carbon-based materials, gold, or silica and carbon.[2,7,8] Actually, using microfabrication to incorporate gold nanoparticles or quantum dots offers new technologies for the creation of highly sensitive and portable biosensors for the cytochrome P450 enzyme for specific applications.[9] Additionally, fiber-optic chemical sensors are particularly relevant in a number of domains, including bio sensing, biomedicine, and drug development. Hydrogels are a new class of materials for fiber-optic chemistry immobilization that have emerged more lately. They are used as DNA-based sensors.[10] Hydrogels immobilize in 3D compared to other materials, allowing for a large loading capacity of sensing molecules.

Silica, Quartz, Crystal and Glass biosensors

Based on their unique characteristics, materials like silica, quartz, or crystal, and glass have been used in recent biosensor development techniques. Given their biocompatibility, abundance, electrical, optical, and mechanical qualities, silicon nanoparticles among them hold the most potential for technical advancements in biosensor applications. Silicon nanoparticles have a broad range of uses, including cancer therapy, biosensing, and bioimaging.[8,11] It's interesting to note that hybrids created when silicon nanowires and gold nanoparticles combine are being used as innovative silicon-based nano-reagents for successful cancer treatments.[11]

Nanomaterials-based biosensors

A variety of nanomaterials, including carbon-based materials like graphite, grapheme, and carbon nanotubes, as well as nanoparticles of gold, silver, silicon, and copper, are utilised to construct biosensor immobilisation.[11-14] Furthermore, materials based on nanoparticles offer excellent sensitivity and specificity for the development of electrochemical and other biosensors. When it comes to metallic nanoparticles, gold has the most potential for use due to its stability against oxidation[15] and near-zero toxicity. In contrast to other nanoparticles, such as silver which oxidise and also have toxic effects when used internally in medicine for purposes like drug delivery.

APPLICATION OF BIOSENSORS

1. In medicinal field

The medical industry uses a variety of biosensors these days. To find a material in sensitive bioelements, these instruments are used in tissues, microbes, organelles, cell receptors, enzymes, antibodies, and nuclear acids. The development of biosensors has yielded remarkable advancements in the medical industry and led to the discovery of new, very potent and precise analytical sensors. According to Chang *et al.* (2017)[16], the medical field contributes in the identification of several processes, including the connection between anticorps, catalytic enzymes, glucose thresholds, microbial diseases, cancer growth detection, pathogens, and toxins. The numerous uses of biosensors in the medical industry are displayed in Table 1.

Table 1- Application of biosensors in the medical field.

Sl. No.	Biosensors	Medicinal applications	References
1.	Uric acid biosensor	Diagnosing a general illness or cardiovascular disease	17
2.	Hydrogel based biosensor	Regenerative health care	18
3.	Nanomaterials-based biosensors	For use in therapeutic application	12
4.	Silicon biosensor	Used in the applications of cancer biomarkers	11
5.	Glucose oxidase electrode-based biosensor and HbA1c biosensor	To cure the diabetes	19

2. In dairy industries

The industry is searching for effective options in response to the growing need for online milk quality verification, and biosensors offer a viable option. A multi-enzymatic aerometric biosensor for lactose in fresh raw milk was created by Eshkenazi *et al*. (2000)[20]. The biosensor's features-simple operation, quick reaction, and extended stability-suggested that this approach might be applied as a low-cost, online lactose testing method in the milk parlour. Additionally, certain biosensors were created to measure milk fat content.[21]

CONCLUSION

In summary, biosensors are a revolutionary invention with enormous potential applications in a variety of industries, such as food safety, environmental monitoring, and medicine. The various kinds of biosensors, their underlying theories, and the most current developments in their field have all been emphasized in this review. Every type of sensor as electrochemical to optical to nanomaterial-based offers special benefits suited to certain uses. Stability, repeatability, and integration into useful devices continue to be obstacles, but further research indicates that innovation will continue to occur. The field of biosensors is rapidly progressing, and it seems likely that in the future, real-time, sensitive detection will be the norm in areas such as environmental sustainability, food quality assurance, and healthcare delivery.

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