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REVIEW ARTICLE

"Biosensor General Principle and their Applications" - An Overview

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ABSTRACT

Nowadays, biosensors are ubiquitous in biomedical diagnosis still as a large point other areas like point-of-care monitoring of treatment and disease progression, environmental monitoring, food control, drug discovery, forensics and biomedical research. Biosensor combines a biological sensor and a transducer, which converts data into an electrical signal. A large range of techniques should be used for the event of biosensors. They are coupling with high-affinity biomolecules that allows the sensitive and selective detection of a spread of analytes. A gift study aims to extensively analyze the most recent biosensors' contributions to detecting respiratory Viruses like COVID-19, Influenza virus, and respiratory synovial virus. This review summarizes as currently available and novel emerging diagnosing methods for detecting common respiratory viruses, like coronavirus, influenza virus, human respiratory synovial virus, human virus, and human rhinovirus. Present challenges and future perspectives of developing the robust biosensors contrivances for expeditious, scalable, and sensitive detection & management of COVID-19 as presented in light of the test-test-test theme for the World Health Organization (WHO).

Keywords: Biosensors, Coronavirus (COVID-19), Detection, Generation and Types, Timeline.

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INTRODUCTION

A biosensor may be a device that measures biological, or chemical reactions by generating signals proportional to the concentration of an analyte within the reaction. Biosensors work within the applications like disease monitoring, drug discovery, and detection of pollutants, disease-causing micro-organisms, and markers are the symptoms of a disease in bodily fluids (blood, urine, saliva, and sweat).[1]

A biosensor is an analytical device that responds to an analyte within the appropriate sample. It interprets its concentration as an electrical signal via an acceptable combination of a biological recognition system and an electrochemical transducer.[2]

Biosensors are useful and have various benefits over current analytical instruments supported these two features: (i) the proximity of the popularity receptors, e.g. antibodies, DNA, aptamers along the transducer; and (ii) its practical size acceptable for fieldwork. Only a second sample is required for detection because the sensitive part of a biosensor is often small.[3]

Biosensor combines a biological sensor and a transducer, which converts data into an electrical signal. Additionally, an electronic circuit will consist of a sign Conditioning Unit, a Processor or Microcontroller, and the Display Unit. It is a tool that converts a biological response into an electrical signal. It detects, records, and transmits details regarding a physiological change or process. It determines the presence and concentration of a selected substance in any test solution.[4]

Nano-sensors are any biological, chemical, or surgical sensory points that convey details about nanoparticles to the macroscopic world. For medicinal purposes, nano-products, like computer chips employed at the nano-scale and nano-robots.[5]

LITERATURE REVIEW

Naru Zhang has reported that tract virus infection caused by viruses or bacteria is one in every of the foremost common diseases in humans worldwide, while this is caused by emerging viruses, like the novel coronavirus, 2019-nCoV that caused by the pneumonia outbreak in Wuhan, China last, have posed great threats to global public health. Spotting the causative viral pathogens of tract viral infections is very important to pick appropriate treatment, save people's lives, stop the epidemics, and avoid unnecessary antibiotics.[6]

Muhammad Asif has reported as we have got summarized and argued about biomarkers and indicators used to detect severe acute respiratory syndrome coronavirus. Antibody detection methods do not seem to be considered and it can suitable to screen individuals at early stages and asymptomatic cases. Therefore, it is urgently needed to develop rapid and sensitive detection methods which may target antigens. Finally, we have

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outlined pros and cons of diagnostic approaches and future directions.[7]

Luis Castillo-Henrique has reported that biosensors are the measuring devices that will sense several biomolecules and are widely used to detect relevant clinical pathogens like bacteria and viruses, showing outstanding results. Therefore, this work aims to present a comprehensive review that exposes how biosensors add terms of bacterial and viral detection. Therefore, the nano - technological features contribute to achieving a faster yet still enceinte COVID-19 diagnosis at the point of care.[8]

METHODOLOGY

Historical Background

The history of biosensors dates back to 1906 when M. Cremer[9] demonstrated that the concentration of an acid in a highly liquid is proportional to the electrical potential that arises in the middle parts of the fluid located on opposite sides of a glass membrane.

However, it was only in 1909 that the concept of pH (hydrogen ion concentration) was introduced by "SorenPederLauritz Sorensen" and an electrode for pH measurements was realized in the year 1922 by W.S. Hughes.[10] In the middle of 1909 and 1922, Griffin and Nelson[11,12] first demonstrated immobilization of the enzyme invertase on aluminum hydroxide and charcoal.

The primary 'true' biosensor was developed by Leland C. Clark, Jr in 1956 for oxygen detection. He is called the 'father of biosensors', and his creation of the oxygen electrode bears his name: 'Clark electrode'.[13] The demonstration of an amperometric enzyme electrode for glucose detection by a Leland Clark in 1962 was followed by discovering the primary potentiometric biosensor to detect the urea in 1969 by Guilbault and Montalvo, Jr.[14] Eventually, in 1975 the primary commercial biosensor was developed by Yellow Spring Instruments (YSI). Table 1 shows the historical overview of biosensors within the period between 1970–1992. Even after the event of an i-STAT sensor, remarkable progress has been attained within the field of biosensors.

The field is now a multidisciplinary area of research that bridges the principles of basic sciences (physics, chemistry, and biology) with the basics of micro/nanotechnology, electronics, and applicatory medicine. The database 'Web of Science' has indexed over 84000 reports on 'biosensors' from 2005 to 2015.

Table 1: Important cornerstones in the development of biosensors during the period 1970–1992

1970	Invention of the ion-selective field-effect transistor (ISFET)
1975	Fibre-optic biosensor for carbon dioxide and oxygen detection by Lubbers and Opitz.
1975	First commercial biosensor for glucose detection by YSI.
1975	First microbe-based immunosensor by Suzuki.
1982	Fibre-optic biosensor for glucose detection by Schultz.
1983	Surface plasmon resonance (SPR) immunosensor by Liedberg.
1984	First mediated amperometric biosensor: ferrocene used with glucose oxidase for glucose detection.
1990	SPR-based biosensor by Pharmacia Biacore.
1992	Handheld blood biosensor by i-STAT.
1996	Launching of Glucocard
1998	Blood glucose biosensor launch by Life Scan Fast Take
Current	Quantom dots, nanoparicles, nanowire, nanotube, etc

Development Timeline [15]

On the other hand, implantable and wearable devices for intravenous drug administration have been greatly developed, many of which are based on MEMS and NEMS. Wearable devices are promising platforms both for sensing and delivery usage. Advanced wearable biosensors have been utilized in many applications.

Generations of Biosensors

There are three generations of biosensors available within the market.

- In first-generation biosensors, the electrons are transferred to molecular oxygen, and also the resulting decrease within the oxygen concentration and/or the produced oxide is measured.
- Second-generation biosensors use artificial, partially toxic mediators or nano-materials to move the electrons to the electrode.
- In third-generation biosensors, the electrons are transferred directly from the enzyme to the electrode with no intermediate stages or use of nanoparticles.

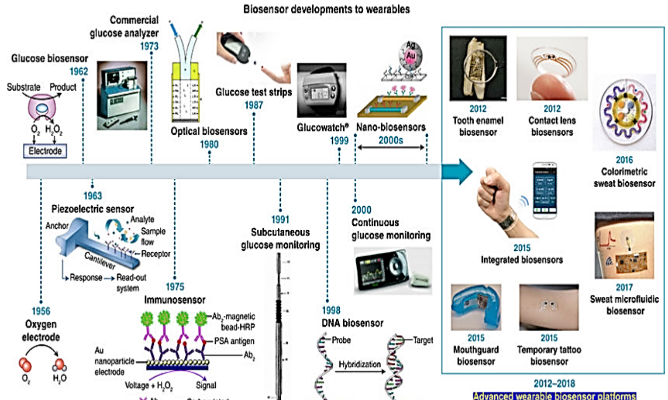

Figure 1: Development timeline for wearable biosensor platforms

Principle of a Biosensors[16]

The desired biological material is typically within the style of an enzyme. A procedure called the Electro-enzymatic approach; can be steps of converting the enzymes into corresponding electrical signals (usually current) with the assistance of a transducer.

One of the commonly used Biological responses is that the oxidation of the enzyme. Oxidation takes action as a catalyst and alters the pH of the biological material. The change in pH will directly affect the enzyme's carrying capacity, which is again in direct respect to the enzyme being measured.

The output of the transducer i.e., this may be a direct representation of the enzyme being measured. This is mostly converted into voltage in order that it may be properly analyzed and represented.

Types of Biosensors[17]

The different types of biosensors are classified based on the sensor device and the biological material shown below.

- Electrochemical Biosensor
  - Amperometric Biosensors
  - Potentiometric Biosensors
  - Impedimetric Biosensors
  - Voltammetric Biosensors
- Physical Biosensor
- Piezoelectric Biosensors
- Thermometric Biosensor
- Optical Biosensor
- Wearable Biosensors

Characteristics of a Biosensor

There are certain static and dynamic attributes that all biosensor possesses. The optimization of these properties is reflected in the performance of the biosensor.

- *LINEARITY* (high) - Linearity of the sensor should be high for the detection of high analyte/substrate concentration.
- *SENSITIVITY* (high) - Value of the sensor response per analyte/substrate concentration.
- *SELECTIVITY* (high) - Chemicals interference have to be minimized for obtaining the correct result.
- *RESPONSE TIME* (short) - Time necessary for having 95% of the response.
- *REPRODUCIBILITY* (high) - The flexibility of the biosensor to come up with identical responses for a duplicated experimental set-up.

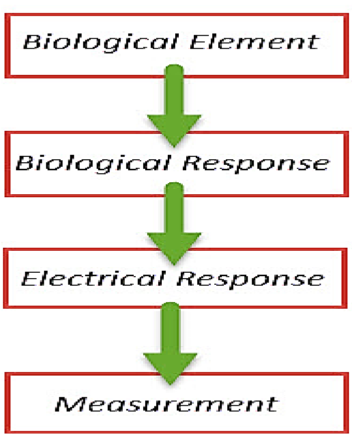

Figure 2: Principle of Biosensors

Ideal Bio-sensors

- The output signal should be relevant to the measurement environment.
- The functional surface should be compatible with the transducer.
- High specificity and selectivity (low interference).
- Sufficient sensitivity and determination.
- Sufficient accuracy and repeatability.
- Sufficient speed of response.
- Sufficient dynamic range.
- Insensitivity to environmental interference or their effects should be compensated.

Application

Biosensors became important within the fields of medication, clinical analysis, and general health monitoring. The benefits of biosensors over lab-based equipment are as follows:

- Small size
- Low cost
- Quick results
- Very easy to use

Apart from the desired medicine and health-based applications, Biosensors have also set up critical applications in several other fields like industrial processing, agriculture, food processing, pollution control etc.

So, the subsequent could be a small list of the potential fields where Biosensors are frequently used.

- Medicine, Clinical and Diagnostic Applications
- Environmental Monitoring
- Industrial Applications

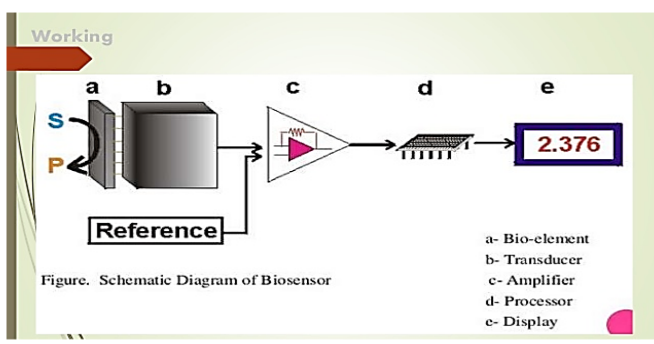

Figure 3: Schematic Diagram of Biosensors

- Food Industry
- Agriculture Industry

Let us briefly take a glance at these areas of application of Biosensors separately.

Medicine, Clinical and Diagnostic Applications

The main area of interest of biosensor is that the Medicine, Clinical and Diagnostics applications. Electrochemical-based Biosensors are commonly employed in biochemical labs and clinics to watch and measure glucose levels furthermore as carboxylic acid.

Commercial Biosensor within the field of non-public health care has become quite popular, especially, self-monitoring of blood sugar. The most advantage of this method is that the blood samples cannot be contaminated and also it is undiluted for more accurate results.

Earlier self-monitoring devices are one-time use applications, i.e., the test is performed for one time, and therefore, the sensor must be disposed of at that time. But advances during this field allow reusable sensors for improved patient care.

Environmental Monitoring

One of the foremost applications of biosensor is within the field of Environmental Pollution Monitoring. Especially, pollution monitoring is a region where Biosensors have a substantial advantage. There are numbering pollutants contaminating water, and as a result, the standard potable is getting worse.

Biosensors with sensing elements for nitrates and phosphates are getting common for battling water pollutants. Another important application is for the military to detect chemicals and unsafe biological specimens used as bio-weapons.

Industrial Applications

Fermentation could be a large industrial operation utilized in dairy, alcohol and other similar products. Large-scale Bacteria and cell culture should be maintained for this purpose. To reduce the production price and harmless fermentation, it is essential to observe these delicate yet expensive processes. Biosensors are designed to observe and measure the generation of a fermented product.

Food Industry

Commercial Biosensors that may measure carbohydrates, acids, alcohol, etc., are already available within the market. Biosensors are employed in the food industry for food internal control for measurement of amino acids, carbohydrates, alcohols, gases, etc. a number of the common food industries are Wine, Beer, Yogurt, soft drinks etc.

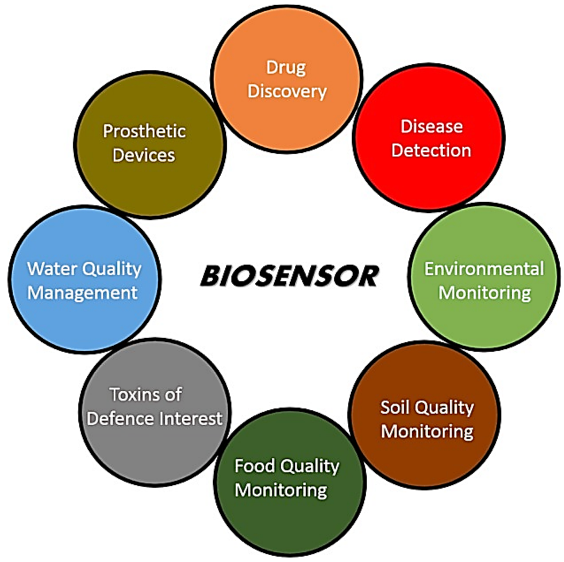

Figure 4: Application of Biosensors

Agriculture Industry

Biosensors within the field of agriculture are generally used for the detection of pesticides.

SUMMARY

- Biosensors are ubiquitous nowadays in several areas of healthcare.
- Pregnancy tests and glucose monitoring sensors are the two leading samples of exceedingly successful biosensor devices.
- A range of transduction techniques like electro-chemical, optical and acoustic are often used for biosensors.
- High-affinity reagents like antibodies, enzymes, and artificial biomolecules will be coupled to the transducer to supply the specificity of biosensors.
- Nanotechnology has had a serious impact on recent advances of biosensing technology

CONCLUSION

- *In vitro*, molecular biosensors are ubiquitous in biomedical diagnosis, likewise as a good range of other areas.
- A range of transduction techniques like electro-chemical, optical and acoustic, will be used for biosensors.
- A range of target molecules and affinity reagents are often used for a large range of biosensors.
- Biosensors are also developed to meet specific needs and maybe highly specific or show a broad spectrum.

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