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BIOMEDICAL APPLICATIONS OF ELECTROCHEMICAL NANOBIOSENSOR

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Abstract: Electrochemical techniques have great promise for low-costminiaturised easy- to- use portable devices for a wide range of applications-in particular, medical diagnosis and environmental monitoring .Electrochemical biosensor holds great promise in the biomedical area due to its enhanced specificity ,sensitivity, label-free nature and cost effectiveness for rapid point- of- care detection of diseases at beside. In thispaper, the working principle of electrochemical biosensor and how it can be employed in detecting biomarkers of diseases. The recent development of implantable biosensors and exploration of nanomaterial in fabrication of electrodes with increasing the sensitivity of biosensor for quick and easy detection of biomolecules .In vivo electrochemical sensing is a well-established technique which offers real-time monitoring through implanted microelectrodes. Electrochemical based detection of heavy metal ions which cause harmful effect on human health.
Keywords: NPs, Nanoparticles, Biomarkers,QDs, Biomarkers, Electroactive species

I. INTRODUCTION

Chemical sensors are sensors that convert the information generated from a chemical reaction of analytes into an analytical signal by using the physical property of the system. Chemical sensors have many applications in industries for process control and monitoring in safety, detection of biochemical agents, environmental protection, drug development, chemical welfare and in-home medical diagnosis .The signal that obtained from the biochemical process are regarded as biosensor. The biosensors have great potential in monitoring environmental hazardsand also in health care.The device that integrates a biological recognition element into a transducer is a biosensor. Components of a biosensor are electrodes, and intermediate matrix between the recognition layer and transducer. Transducer plays an important role in defining the stability, selectivity and specificity of biosensor [2]

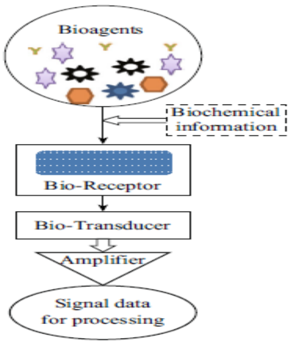

Fig.1.Basic principle of biosensor

Fig 1 shows the biomolecules incorporated in to a solid matrix that holds the sensing analyte. On the basis of principle of transducer biosensors are classified shown in Fig.2. there are two major transduction mechanism such as optical and electrochemical sensors are, respectively, are based on the light intensity and the electrical distribution that plays an important role in the majority of the biosensors. The electrochemical sensors have huge potential and most suitable in biomedical applications . By using different nanomaterials, biosensors can offer a variety of biomolecules to be identified with more specificity and sensitivity.

In electrochemical sensor, the transducers in the sensor converts the biological events in to an electrical signal. The two commonly used parameter arenanoparticles(NPs) and quantum dots(QDs) have been used for bio sensing. Nanomaterials are used in modifying the electrochemical transducer to improve the

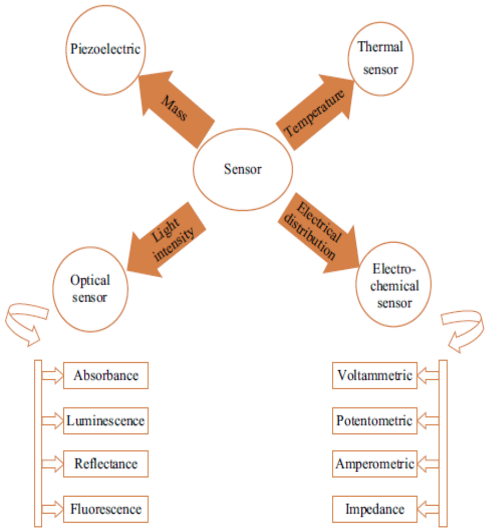

Fig.2.Schematic showing classification of biosensor

transfer of electron in an analytical application and provide biocompatible micro environment to biomolecules.Recently, efforts are being made to use nanostructured modifiedelectrodes for monitoring specific biological speciesin vivo [8] which opens up the possibility to detect aspecific molecule in living organisms.

II. ELECTROCHEMICAL BIOSENSOR

To improve the effectiveness of disease treatment, the early diagnosis of the disease is an important issue which has to be resolved. To measure the extremely low level of markers and detect the early stages of diseases highly sensitive sensors are required. Electrochemical sensors are considered to be high sensitive and it can be easily miniaturised and have fast response .Electrochemical sensors read out the chemical information from a sample and converts the data in to analytical information. The information may be from the physical property of the system or the reaction of a species that present in the system. The data received from the receptor unit are transferred to a transducer unit and that converts them in to analytical output

Electrochemical sensors are widely used to identify markers of different diseases like cardiac diseases, cancer , acquired immunodeficiency syndrome, hepatitis and urinary infections. A variety of electrochemical analysis methods which are amperometric, voltammetric, conductometric and impedimetric. Miniaturised implantable electrochemical biosensors are considered as an important tool in vivo sensing of various metabolites like blood glucose, triglycerides and cholesterol to various protein biomarkers, bacteria and viruses without it requires patient intervention and its physiological state

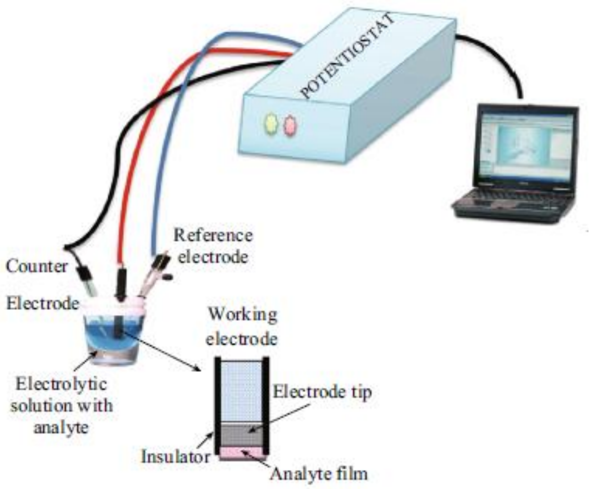

Fig.3.Illustration of electrochemical biosensor

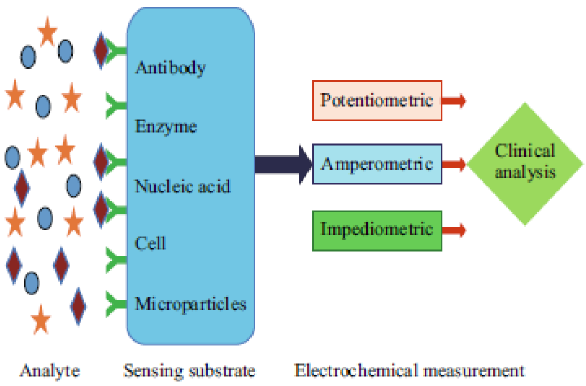

Fig.4.Electrochemical sensing of biological species

III. BIORECEPTORS IN ELECTROCHEMICAL SENSING

3.1 Enzymes

Enzymes act as an important biomarker for the analysis of several diseases through electrochemical detection. These are generally protein molecules of oxidase type that can be selectively react with target analyte . Enzymes can be easily immobilized on the surface of the electrode by physical absorption, covalent bonding and various techniques.

3.2 NUCLEIC ACID

Nucleotide(DNA or RNA) sequences are also used as biomarkers, the single stranded DNAs are immobilised as biorecognition elements and if the complementary sequence is present in the sample, binding occurs and electrochemical response is generated. These detectionsoccurs by complementary binding of nucleotides like adenine (A) to thymine (T) and cytosine (C) to guanine (G). The DNA-based recognition elements, aptamers, whose function is analogous to antibodies, bind to the target and generate signal of recognition.

3.3 CELLS

The cells are also regarded as an important bioreceptor as they are highly sensitive to the environment. Cells get easily immobilised on the surface of electrodeand it functions as abiorecognition layer to frequently detect parameters like toxicity, stress and effect of drugs. When cell is used for biorecognition, cell membrane recognizes the element present in the solution such as aptamers, antibodies or small cell vesicles.

3.4 ANTIBODIES

Antibodies are protein molecules those are obtained from B-lymphocytes in any kind of antigenic stimulation.These are immobilized on the electrode surface through covalent bonds such as thiol, amide, ester, etc. The electrochemical immunosensor for prostate-specific antigen (PSA) detection has been developed using silver hybridized mesoporous silica nanoparticles (Ag@MSNs) as an electrode material and hydroquinone (HQ) as a mediator

IV. IN VIVO APPLICATIONS OF ELECTROCHEMICAL SENSORS

Vivo electrochemical sensing is a well-established technique which offers real-time monitoring of analyte through implanted micro electrodes. These sensors are decorated by making amperometric changes that depict biological events such as enzymatic activity

4.1 GLUCOSE SENSORS

In the monitoring of glucose, the glucose oxidase is immobilized on the electrode surface to detect the electron transfer process. The glucose electrochemical sensors are embedded within blood vessels that are directly linked to signal processing unit and implanted wires for supplying power . The different types of glucose monitoring systems are Continuous Glucose Monitoring System(CGMS), Guardian TM System, Glucowatch Biographer.

4.2 NEUROCHEMICAL SENSING

For analyzing the brain's extra cellular chemical environment has the potential to provide a significant insight in to neurotransmission, pharmacology and the behavior. Vivo electrochemical sensing have more application in the field of neuroscience. The vivo monitoring provides us the information about the working of the neural networks whether they are active or not

V. HEAVY METAL ION DETECTION

Heavy metal ion detection is used in the detection of diseases like cancer and malaria. Blood and urine is recognized as best non-invasive method for monitoring a wide range of toxic metal ions, this detection is important for detecting various diseases. Heavy metal ion detection has been an issue due to protein competition and electrode fouling. This type of electrochemical sensors used in the detection of different heavy metal ions in various types of diseases

VI. CHALLENGES AND FUTURE ASPECTS OF ELECTROCHEMICAL BIOSENSOR

In medical diagnostic it requires a rapid, accurate and portable system that could easily be available in patient's beside with real-time monitoring system. Now electrochemical sensing faces some challenges that should be sorted out to get a highly sensitive and selective system for the diagnosis of diseases. The other challenge in the future development is in vivo analysis of samples conveniently. The ideal in vivo biosensor should be biocompatible, stable for longer period, sensitive and non toxic to host. As the nanoparticles are biocompatible, toxicity detected by the other sensors can minimized. The nanoparticles show less reactivity to proteins and not have the capability of eliciting immune response. The advances in the miniaturization of the device, wireless power and data transmission all promise to reduce the invasiveness of many in vivo electrochemical sensors.

VII. CONCLUSION

Sensors with high sensitivity are required to measure extremely low level of biomarkers and detect early stages of diseases. Electrochemical sensors are considered as the best candidate that have fast analytical time, label-free nature and higher sensitivity and specificity

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