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**RESEARCH ARTICLE**

**Theoretical Study of Biosensors and It's Application into Physical Science**

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***Abstract***

Biosensors are an amperometric enzyme electrode for glucose. In this paper, describe how to make electrochemical sensors more intelligent by adding enzyme transducers and membrane enclosed sandwiches, why Biosensors are important, its components, characteristics, detection and applications, Limitations etc.



## Introduction

A biosensor is an analytical device which converts a biological response into a measurable signal. Biosensors are used to determine the concentration of substances and other parameters of biological interest without using the biological system directly.

Biosensors are a reagent less system in which reagents are already immobilized. There is therefore need not be added by the user.

A sensor that integrates a biological element with a physiochemical transducer to produce a signal proportional to a single analyte which in turn is conveyed to detector.

Biosensors are sophisticated tools that can be used for detection and monitoring. New technology is allowing more specificity, quicker and more accurate measurement / output. New methods and uses for biosensors continue to grow with increasing demand (Arya, *et al.*, 2006).

**Why Biosensors are important?**

There is a pressing need for cheap, fast, and easy to use analytical tools during the last decades. Biochemical sensors have emerged as a dynamic technique for qualitative and quantitative determination of different analytes for environmental, clinical, agricultural, food or military applications. Study of bio molecules and how they interact with one another e.g. Biospecific interaction analysis (BIA) (Fig- 1).

- Drug Development — Environmental field monitoring
- In-home medical diagnosis — Scientific Crime detection
- Quality Control in a food factory — Food analysis

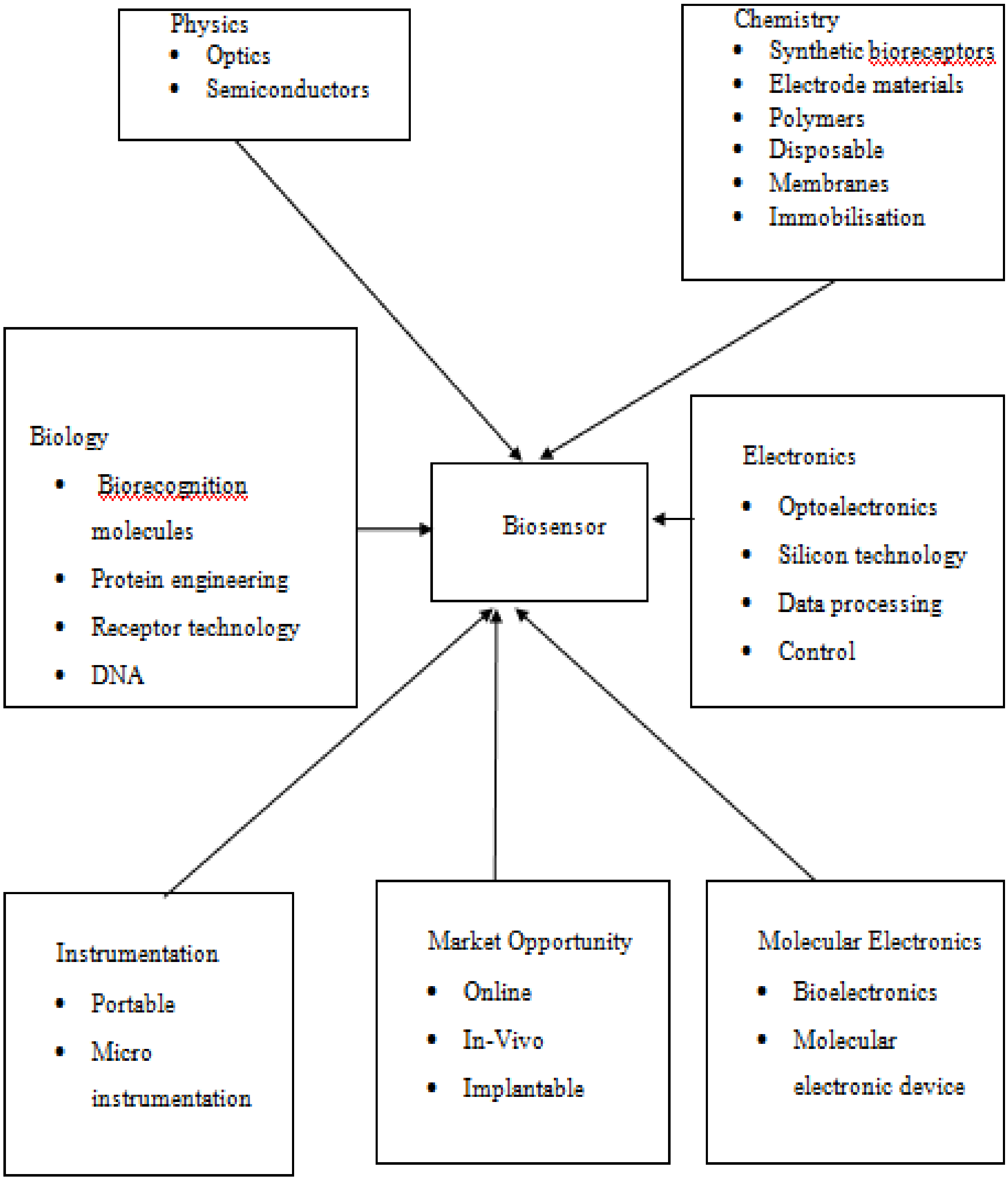


**Fig- 1:** Biospecific interaction analysis (BIA).

Biosensors are very much important in medical science also.

In Mid 1950's Leland C. Clark invented an electrode that measures dissolved oxygen in the blood of patient undergoing surgery. He surrounded a platinum electrode and reference electrode with a plastic membrane permeable to gases. The voltage differential measured between the two gives the rate at which the oxygen was being diffused.

In Vitro medical diagnostic biosensor application areas are shown in (Fig- 2):

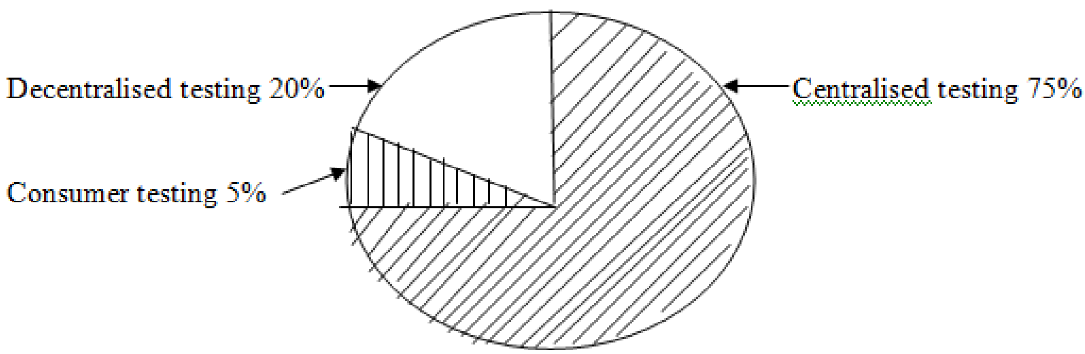


**Fig- 2:** In Vitro medical diagnostic biosensor application areas.

**Components of a Biosensor:**

1st component: Biological element

The component used to bind target molecule must be highly specific, stable under storage conditions and immobilized.

- Microorganism
- Tissue
- Cell
- Organelle
- Nucleic Acid
- Enzyme
- Enzyme component
- Receptor
- Antibody

2nd component: Physiochemical Transducer

Acts as an interface, measures the physical change that occurs with the reaction at the bio receptor then transforming that energy into measurable output.

| | | |
|---|---|---|
| Electro active Substance | → | Electrode |
| pH change | → | Semiconductor pH |
| Heat | → | Thermistor |
| Light | → | Photon Centre |
| Mass change | → | Piezoelectric Device |

3rd component: Detector

Signal from the transducer is passed to a microprocessor wherein it is amplified and analysed. The data is then converted to the concentration units and is displayed / Stored onto a data storage device (Ramsay, 2004).

**Characteristics of a Biosensor:**

- Specificity
- Sensitive within biological range
- Stable for several months
- Able to be used 5000-10,000 times
- Self life should be at least six months
- Capable of miniaturization
- Fast response
- Must not be poisonous
- Sensitivity
- Low detection limit

- Cost
- Simplicity
- Reliability
- Speed
- Accuracy
- Precision
- Utility
- Field Portability
- Ruggedness
- Reproducibility
- Ease of calibration
- Stability
- There should be Room for improvement.

Linearity:- Maximum linear value of the sensor calibration curve. Linearity of the sensor must be high for the detection of high substrate concentration.
Sensitivity:- the value of the electrode response per substrate concentration.
Selectivity:- Interference of chemicals must be minimized for obtaining the desired result.
Response Time:- The time required for obtaining 95% of the response (Gerard *et al.*, 2002).

**An ideal biosensor:**

Must be highly specific for the purpose of analysis, be stable under normal storage conditions and show good stability over a large number of assays. The reaction should be in dependent of such physical parameters such as stirring pH and temperature as is manageable. This would allow the analysis of samples with minimal pre-treatment. The response should be accurate, precise and reproducible. If the biosensor is to be used for in Vivo monitoring in clinical situations, the probe must be biocompatible. The complete biosensor should be dumping proof. There should be a market for the biosensor.

**Commercial Glucose Biosensor:**

- Biggest biosensor success story
- Diabetic Patients monitor blood glucose at home
- First made by Clark in 1962,now 5 or more commercial test systems
- Rapid analysis from single drop of blood
- Enzyme-electrochemical device on a slide (Saha *et al*., 2009).

**Principle of Detection:**

Piezoelectric–electric Biosensors:

Some piezo-electric devices utilize crystals, such as quartz, which vibrate under the influence of an electric field. The frequency of this oscillation depends on their thickness and cut. Others use gold to detect the specific angle at which electron waves (Surface Plasmon) are emitted when the substance is exposed to laser light. The change in frequency is proportional to the mass of absorbed material.

Electrochemical Biosensors:

Amperometric for applied current: Moment of e- in redox reactions is detected when a potential is applied between two electrodes.

Potentiometric for voltage: Change in distribution of charge is detected using ion-selective electrodes, such as pH-meters.

Optical Biosensor:

Colorimetric for Colour: Measures change in light absorption as reactants are converted to products.

Photometric for light intensity: Photo output for a luminescent or fluorescent process can be detected with photomultiplier tubes or photodiode systems.

Calorimetric Biosensor:

If the enzyme catalyzed reaction is exothermic, two thermostats may be used to measure the difference in resistance between reactant and product and, hence, the analytic concentration (Chaubey and Malhotra, 2002).

**Application of Biosensors:**

1. DNA-Sensors: Genetic monitoring, disease.
2. Immunosensors: HIV, Hepatitis, other viral diseases, drug testing, environmental monitoring.
3. Cell-based sensors: Functional sensors, drug testing.
4. Point of Care sensors: blood, urine, electrolytes, gases, steroids, drugs, hormones, proteins, other.
5. Bacteria Sensors: (*E. coli*, *Streptococcus*, etc.) Food industry, medicine, environmental etc.
6. Enzyme Sensors: Diabetes, drug testing.
7. Environmental Applications: Detection of environmental pollution and toxicity. Agricultural monitoring, Ground water screening, Ocean monitoring, etc.

**Cancer Monitoring:**

Biosensors can play a very important role for early cancer detection in body fluids. The sensor is coated with a cancer specific antibody or other biorecognation legends. The capture of a cancer cell or a target protein yields electrical, optical or mechanical signal for detection. Biosensors in process control can be use to measure materials during flow or temperature/Pressure/acidity variation. The development of biosensor in industry can improve manufacturing techniques, which would allow for a wider range of sensing molecules to be produced at a cheaper rate. In the field of medicine, tumour cells can be used as a bio sensing elements to monitor chemotherapeutic drug susceptibilities. Biosensor can also play important role in the manufacture of pharmaceuticals and replacement organs such as an artificial pancreas. Biosensors can be widely used in environmental testing by using a flow through system to monitor waste water. These sensors are not only restricted to the use of molecules. Living microorganisms such as bacteria can be used to detect substances such as Vitamin B-12 (Chaubey and Malhotra, 2002).

**Limitations of Biosensors:**

Most existing limitations are directly related to operational or long term stability of the biological receptor and/or the physical transducer.

Other limitations could be attributed to poor reproductibility between sensors and selectivity in complex matrices.

For practical applications, the most important obstacles are encountered once the sensor is used outside pristine laboratory conditions and is applied for in situ real sample monitoring. (Arya, *et al*. 2009)

**Why Metal Oxide for Biosensors**?

Nanostructured metal oxides have unique properties including ------

- High specific surface area
- Biocompatible
- High chemical stability
- Electrochemical activity
- High adsorption capacity
- High electron communication
- Negligible swelling in both aqueous and non-aqueous solution in comparison to organic polymers.(Ansari, *et al*. 2009)

## Conclusion

Most biosensors show excellent characteristics for synthetic samples, pristine laboratory samples, they are, however, not yet sufficiently robust in real samples.

Biosensors play a part in the field of medicine, environmental quality, and industry, mainly by identifying material and the degree of concentration present.

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