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REVIEW ARTICLE

GLUCOSE BIOSENSORS FOR DIABETES: A REVIEW

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ABSTRACT

Diabetes is the most common disease currently affecting the more than 371 million people. Blood glucose irregulation is the main cause of diabetes. Many methods are currently available such as artificial pancreas which consist of the glucose sensors, insulin pump and controller. The process of testing blood glucose level was quite tedious in past days. But now a days glucose biosensors are used to test the blood glucose level. The currently available biosensors are electrochemical type. These glucose biosensors are very sensitive, easy to maintain and their cost is too low. Glucose biosensors are basically based upon the oxidation of glucose with molecular oxygen. But still many important challenges remaining to achieve a reliable glucose monitoring device.

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INTRODUCTION

Diabetes is becoming a major health problem in today's life. The main cause of this problem is increasing obesity, sedentary life style etc. Energy source in human body is glucose. Two hormones insulin and glucagon are necessary to regulate the blood glucose level. When blood glucose level increases than alpha cell tried to maintain the glucose level. When blood glucose level decreases than beta cell tried to maintain the blood glucose level. Biosensors are used to measure the level of blood glucose. Biosensor means the group of devices used to monitor the living system. Biosensor are the devices which are made up from the transducer and a biological element they may be an enzymes or nucleic acid. Diabetes mellitus requires a monitoring of level of blood glucose .Biosensors made from electrochemical play a vital role in this direction. The review consist the history of biosensors, principle of biosensors, recent development in biosensors, major techniques for enhancing the performance, future scope and use of biosensors in various fields.

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There are various types of biosensors

- **Blood Glucose Biosensor:** It uses the enzyme glucose oxidase to break blood glucose level. The result measure the concentration of glucose level. In blood glucose biosensors electrode is the transducer and enzyme are active component.
- **Optical Biosensors:** These biosensors are based upon the principle of surface Plasmon resonance. These types of biosensors are used in lasers.
- **Canary Biosensors:** These biosensors are used by the minors. In these days all types of biosensors perform similar functions.
- **Continuous Biosensors:** These type of biosensors suffer from drift. But use of these type of biosensors are very economical.

History of Biosensors

Leland C. Clark was an American biochemist known as the father of biosensors. Biosensors are used by million people for checking glucose level. History of biosensors start in 1962. First biosensor device was developed by Clark and Lyons. First glucose monitoring biosensor examine oxygen consumed by the enzyme reaction.

- In 1962 first biosensor for glucose called amperometric enzyme electrode was developed by Clark.
- In 1969 biosensor for urea called potentiometric biosensor was developed by Montalvo.
- In 1970 biosensor called ion selective field effect transistor was by Bergveld.
- In 1975 First commercial biosensor was developed.
- In 1976 biosensor was developed for artificial pancreas.
- In 1980 biosensor was developed for vivo blood gases.
- In 1982 fiber optic based biosensor was used for monitoring glucose level.
- In 1983 biosensor for plasma resonance immunosensor was developed.
- In 1984 first mediated amperometric was developed.
- In 1987 blood glucose monitoring biosensor was launched.
- In 1990 SPR based biosensor was launched.
- In 1992 first handheld biosensor was launched.
- In 1998 blood glucose detecting biosensor was developed.

Working Principle of Glucose Biosensors

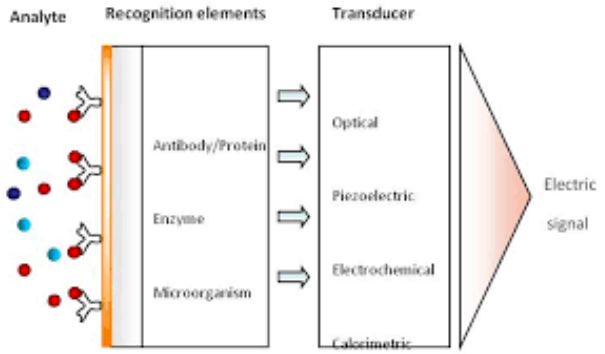
There are three main parts of glucose based biosensors.

- In the presence of chemicals, there is a biological recognition element.
- A transducer that convert biological recognition output into signal which can be measured.
- Signal processing system which convert signal into the form which can be readable.

Recognition

It contains enzymes, receptor, nucleic acid, antibodies and microorganisms.

Transducer: There are various type of transducer like optical, thermometric and electrochemical.



Current used biosensors are electrochemical type. Electrochemical biosensors are highly sensitive and easy to maintain. These biosensors have a low cost. Amperometricglucose biosensor is currently available in these days. Amperometric biosensor generate current when electrons are exchanged between electrode. Glucose of diabetic patient can be measured by using three enzymes.

- Glucose oxidase
- hexokinase
- Glucose-1-dehydrogenase

The glucose biosensor based upon glucose oxidase and glucose-1-dehydrogenase are differ in their potential, cofactors and how to select glucose. Glucose oxidase is basic enzyme used in biosensors. Glucose oxidase enzyme is easy to obtain and pH value of this enzyme is greater. Immobilized glucose oxidase catalyzed the oxidation of beta- D glucose with molecular oxygen. Flavin adenine dinucleotide (FAD) is required for proper reaction.

Glucose + GOx + FAD→ Glucolactone + GOx + FADH2

Characteristics of Biosensors

Following are the important characteristics of biosensors.

- **Sensitivity:** The value of electrode response depend upon the concentration of substrate.
- **Selectivity:** We can minimized the chemicals according to the results.
- **Linearity:** Biosensor have a high linearity when the concentration of substrate is high.
- **Response Time:** Response time should be 95% for biosensor.

Different Generations of Glucose Biosensors

First Generation: This generation biosensors are based upon the use of natural oxygen .Natural oxygen was used as the substrate. This generation detected the amount of hydrogen peroxide produced. The problem with these generation biosensors is that it required higher potential for measurement of hydrogen peroxide.

Second Generation: The limitation of first generation biosensor were overcome by second generation biosensors. These biosensors replaced the use of natural oxygen by electron acceptor called redox. Electrochemical glucose biosensors for self-monitoring for diabetic patient were developed during the time period of this generation. The self-monitoring biosensors are based upon the ferrocene.

Third Generation: This generation biosensors are based upon the direct transfer between enzyme and electrode without using mediators. Direct transfer of electron take place in this generation. This was occur by using conducting material. Conductive organic salt such as TTF is used.

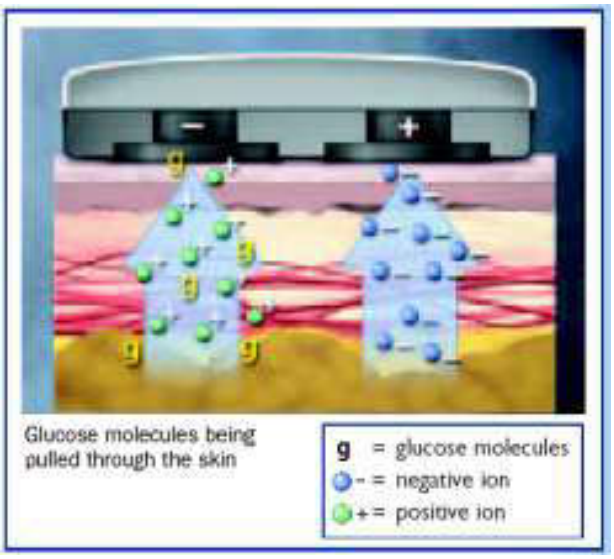
Latest Biosensors

There are two types of Biosensors used these days:

- Continuous glucose monitoring System
- Non-invasive glucose monitoring

Continuous Glucose Monitoring

Most of these glucose biosensors does not measure blood glucose directly.In these type of biosensors needle type electrodes measure the concentration of blood glucose.



Non Invasive Glucose Monitoring

The gluco-watch biographer was the first transdermal glucose sensor approved by US. The watch was based upon transdermal reaction. But still there is no any reliable non-invasive glucose monitoring device is available.

Use of Non material: The glucose biosensor is used to measure the level of blood glucose. It contain enzymes, analytic for measuring glucose. Another non -materials are also used to measure the level of blood glucose.

- Gold, nanotubes are used to measure the level in glucose biosensor.
- Magnetic, nanoparticle are also applied on biosensors.
- Quantum dot is also applied on biosensors for their physical, chemical properties.
- GNP, CNT are also used in biosensors.
- SiO2 gel is also applied on biosensors.

Conclusions

Glucose biosensor is important device for the patients suffering from diabetes. Still research is going to improve electrodes, membrane. The ADC recommends that accuracy of these devices should be greater than 5%.But still many of these devices don't meet to this challenge. Biosensor devices are accurate less than the ADC level. There are many important factors which still need to improve. The major is problem with these devices is incorrect use of strip, used these devices with dirty hands, and lack of quality control. Quality control of these devices should be based on the manufacturer instruction. Very elegant research on the sensing devices opened the door for new researches in electrochemical biosensors. Technology enhancement has improved the quality of electrochemical biosensors in these days.

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