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A STUDY ON SELF-MONITORING GLUCOSE SENSING WITH MULTI-PARAMETRIC SURFACE PLASMON RESONANCE

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Abstract- **Diabetes is a metabolic disease and in an ideal diabetic diet, a number of factors must be taken into consideration, including the amount and type of carbohydrates consumed as well as the amount of fiber, fat, and protein contained in foods. Glycemic index and glycemic load are further considerations. Foods with low glycemic index and load raise blood sugar more slowly than high glycemic index / load foods. In turn the glycemic index refers to a standardized measurement, while glycemic load takes a typical portion size into account. The total daily calories are evenly divided into three meals. By the Electrochemical Glucose Measurement electrically coupling glucose oxidase to nanoscale carbon structures modulates the electrical resistance of the structures. Many researches do their work on all add-on devices that could allow the smart phone to take pregnancy tests or monitor diabetes. A smart phone can be combined with a tiny sensor and wearable insulin pump, for pancreas to monitor the blood-sugar levels and to deliver insulin as needed. So this can be the future to monitor the diabetes foe evaluating the treatment. One among the technique is Multi-Parametric Surface Plasmon resonance (MP- SPR) binding analysis methodology is used to study molecular interactions The Biosensor can determines the presence and concentration of a specific substance in any test solution. Biosensors can be incorporated with the add-on devices and it can be monitored according to the necessary period of time .With this usage we can have the better sensitivity, reproducibility, and easy maintenance as well as their low cost.**

Index Terms- **Blood glucose, Diabetes mellitus, Electrochemical Glucose Measurement, Self-monitoring of blood glucose, MP-SPR Biosensor**

I. INTRODUCTION

A biosensor is a device that combines a biological recognition element together with a transduction system for the detection of a specific analytic. The biological component can comprise species such as a redox protein or enzyme, an antibody, a whole cell or a DNA strand and serves the purpose of imparting specificity to the sensor. The first biosensor, for the measurement of glucose was developed by Clark in 1962 and subsequently developed commercially with the first product released in 1973. Later then there have been an enormous number of reports on biosensors [3].

Biosensors are analytical tools for the analysis of bio-material samples to gain an understanding of their bio-composition, structure and function by converting a biological response into an electrical signal. The biological response of the biosensor is determined by the bio catalytic membrane which accomplishes the conversion of reactant to product. Immobilized enzymes possess a number of advantageous features which makes them particularly applicable for use in such systems. They may be re-used, which ensures that the same catalytic activity is present for a series of analyses. In an electrochemical cell, the oxidation can take place at the surface of an electrode, releasing electrons into an electrical circuit, which can be measured as a current [1].

II. GLUCOSE DETECTION

The concentration of glucose can be determined easily using HPLC and is usually performed in this manner in fermentation systems etc. Such methods clearly do not lend themselves to the type of testing required for a diabetic patient. The only alternative method relies on enzymatic analysis given below equation by the enzyme glucose oxidase (GOx) which contains the co-factor, flavin adenine dinucleotide (FAD). The oxidized form of the enzyme (GOx (FAD)) catalysis the oxidation of glucose and is itself reduced in the process. Subsequently, the reduced form of the enzyme (GOx (FADH2) is oxidized by O2 to regenerate the oxidized form of GOx [3] [4].

Glucose detection for home use has the additional requirements like using an undiluted whole blood sample of volume less than 1 ml and a disposable, etc. The sensor with a stable calibration is required with no requirement for additional reagents with low cost. Measurement of the reduced form of glucose oxidase is complicated by the fact that the flavin group is buried deeply within the amino acid matrix, rendering electron transfer to and from the redox active site and the electrode difficult. In contrast the concentration of H_2O_2 can be performed in a relatively straight forward manner at a platinum electrode, albeit at a relatively high potential of 0.6 V [3].

III. GLUCOSE BIOSENSORS

Glucose test systems have been available for home use since the 1950's when Ames, Inc. released urine test strips. The system was nor\t successful and the test was relatively complex. The utilization of urine samples requires accurate timing by the patient. With these systems, the timing of the test had to be controlled by the patient, leading to significant errors in the results. The concentration of glucose was determined by comparing the Colour change on the strip with a standard series of Colour changes. The spectrophotometric detectors require insertion of the test strip into the detector and require the patient to clean the detector on a regular basis. Electrochemical based biosensors now dominate the market as the sensors for such devices are cheaper to manufacture. In 1987, Medicine, Inc. released the first electrochemically based glucose biosensor for home use. A key feature of the device was that it relied on the process of screen printing to produce the electrodes. This process was well established, low cost and amenable to the mass production of sensors [4].

IV. PERFORMANCE

The performance of these sensors was reasonable for home use but did not meet the levels of accuracy and precision of clinical instruments. The advantages that these tests offer in comparison to larger, more accurate laboratory based tests lie in their ease of use and their portability, which enables diabetics to test their blood glucose levels as part of their normal daily routine.

More recent advances in glucose sensors lie in the development of implantable devices capable of determining the concentration of glucose, with the results of the analysis fed to a controller which can then automatically determine the amount of insulin required at that particular time and deliver the insulin via an implanted pump. The development of such devices represents the culmination of decades of effort to develop an artificial pancreas, which would enable diabetics to counteract much of the debilitating features associated with the condition. To date, such devices have been show to perform at reasonable levels of accuracy for periods of a few days but suffer from deteriorations in response over longer times due to fouling, adhesion, etc [6].

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V. ADVANCEMENTS IN GLUCOSE SENSORS

Glucose biosensors have been successfully developed mainly because a large section of the population suffers from diabetes. The prevalence of diabetes forms the basis for a large market with a considerable financial incentive to develop and market home use blood glucose tests. In addition to an adequate market need and size, testing for glucose also meets the other criteria essential to the successful development of a sensor which include: a cheap and stable bio recognition element; a reasonably high analytic concentration; the ability to mass produce sensors on a scale of millions per day; a disposable, single use system with a stable shelf life of greater than 18 months at room temperature; small sample volumes; no requirement for additional reagents; low cost and ease of use.

Blood glucose monitoring is a way of testing the concentration of glucose in the blood for glycaemia. Particularly important for diabetes mellitus, a blood glucose test is performed by piercing the skin like finger to draw blood, then applying the blood to a chemically active disposable 'test-strip'. Different manufacturers use different technology, but most systems measure an electrical characteristic, and use this to determine the glucose level in the blood. The test is usually referred to as capillary blood glucose.

A. Healthcare with Technology

Healthcare professionals advise patients with diabetes on the appropriate monitoring regime for their condition. Most people with Type 2 diabetes test at least once per day. Diabetics who use insulin usually test their blood sugar more often (3 to 10 times per day), both to assess the effectiveness of their prior insulin dose and to help determine their next insulin dose.

Improved technology for measuring blood glucose is rapidly changing the standards of care for all diabetic people. A blood glucose meter is an electronic device for measuring the blood glucose level. A relatively small drop of blood is placed on a disposable test strip which interfaces with a digital meter. Within several seconds, the level of blood glucose will be shown on the digital display [7].

It needs only a small drop of blood for the meter means that the time and effort required for testing is reduced and the compliance of diabetic people to their testing regimens is improved. Although the cost of using blood glucose meters seems high, it is believed to be a cost benefit relative to the avoided medical costs of The complications of diabetes.

B. Advancements in software

There is an option for alternate site testing which uses the same test strips and meter, is practically pain free, and gives the real estate on the finger tips a needed break if they become sore. The disadvantage of this technique is that there is usually less blood flow to alternate sites, which prevents the reading from being accurate when the blood sugar level is changing.

Older systems required ‘coding’ of the strips to the meter. This carried a risk of ‘miscoding’, which can lead to inaccurate results. Two approaches have resulted in systems that no longer require coding. Some systems are 'auto coded', where technology is used to code each strip to the meter. And some are manufactured to a ‘single code’, thereby avoiding the risk of miscoding. Some systems use a cartridge or a disc containing multiple test strips. This has the advantage that the user does not have to load individual strips each time, which is convenient and can enable quicker testing.

Most new systems come with software that allows the user to download meter results to a computer. This information can then be used, together with health care professional guidance, to enhance and improve diabetes management. The meters usually require a connection cable, unless they are designed to work wirelessly with an insulin pump, or are designed to plug directly into the computer [7].

VI. GLUCOSE SENSING BIO-IMPLANTS

The use of test strips has shown that the required self-injury acts as a psychological barrier restraining the patients from sufficient glucose control. As a result, secondary diseases are caused by excessive glucose levels. A significant improvement of diabetes therapy might be achieved with an implantable sensor that would continuously monitor blood sugar Levels within the body and transmit the measured data outside. The burden of regular blood testing would be taken from the patient, who would instead follow the course of their glucose levels on an intelligent device like a laptop or a smart phone. Since the implantation of a sensor into the body is accompanied by growth of encapsulation tissue, the diffusion of oxygen to the reaction zone is continuously diminished. This decreasing oxygen availability causes the sensor reading to drift, requiring frequent re-calibration using finger-sticks and test strips.

VII. GLUCOSE SENSING WITH ELECTROCHEMICAL METHODS

Diabetes management that involves drawing blood from the patient several times a day is invasive and uncomfortable, to say the least. Continuing research in electro analysis allows measurement techniques for glucose concentration that are not only becoming faster and more accurate, but also operate on much lower volumes of blood. With the development of these methods, it is possible to decrease the discomfort of diabetes management as we know it today. Electrochemical methods for glucose sensing are based on glucose oxidase (GOx), a biologically occurring enzyme that oxidizes the glucose molecule to laconic acid. In an electrochemical cell, however, this oxidation can instead take place at the surface of an electrode, releasing electrons into an electrical circuit, which can be measured as a current.

VIII. GLUCOSE SENSING WITH SIMULATION SOFTWARE

Many manufacturers of glucose sensors came out with technological replacements often. Product development at the present time has moved beyond the proof-of- concept stage through to an effort to create a state-of-the-art product: the optimal glucose sensor, within the constraints of cost and manufacturing difficulties. An electrochemical glucose sensor implementation can be complex as the sensor must work under a range of conditions; clever design is required to ensure that a measured current can still be directly correlated to the glucose concentration in the sample. Practical difficulties may include varying oxygen concentration in blood, the presence of other chemical species in the blood that react similarly to glucose, and the change in temperature of the sensor due to blood being supplied at body temperature.

COMSOL Multiphasic with its Model Library is an ideal tool for real-world 2D and 3D problems in electro analysis with non- standard or complex phenomena, such as enzyme kinetics, can be incorporated into the model. Often, the theoretical model is developed by experimental setup of the behavior of the electrochemical system. Therefore, the numerical modeling approach must remain flexible. The digits that are usually much longer than they are wide, their length can be ignored and the problem can be simplified to a 2D unit cell [6].

The researchers found that the readings of the sensor can run through an application on a smart phone which provides the real-time results. When properly provisioned, the smart phone user has the ability to monitor multiple types of body fluids, including blood, urine, saliva, sweat or breath. In case of medical applications, the sensor readings can be combined with the GPS signal of a smart phone and users can then be guided to the next drug store, hospital or the any other way.

IX. MULTI-PARAMETRIC SURFACE PLASMON RESONANCE

The Multi-Parametric Surface Plasmon Resonance (MP-SPR) is an absolute measurement due to optics goniometric arrangement and the measurement in a wide angular range enabling the whole SPR curve monitoring. It follows the peak minimum position, total internal reflection along the peak minimum intensity parameters and gets more information about interaction between them. Pure Kinetics™ enabling inline measurement of bulk effect for the measurement of real time can be enforces the molecule interactions for both affinity and kinetic as well as thickness and refractive index for ensuring it.

X. PARAMETER MEASUREMENT

The parameters for angular position of SPR peak min is the only parameter measured by traditional SPR. It is typically presented in a traditional SPR sonogram. The Intensity of SPR peak minimum depends on the sensor material and the media. Unlike others, SPR Navy™ is able to measure in liquid as well as in gas, on metals, metal oxides and hydrogels. The Total Internal Reflection (TIR) value is dependent on the bulk properties around the sensor and it is utilized for db/dc calculation [6].

Its width at 3 different levels defines the shape of the SPR peak which contains information on light absorption by the binding molecules and therefore, enables characterization of absorbing coatings and samples. There is another wavelength pair which can be used for all measurements and also resolves the layer thickness [7].

XI. RESULTS

Surface Plasmon resonance is a phenomenon commonly used for bio sensing, but typically it needs a large laboratory equipment which involves both a light detector and a light source. Providentially, smart phones have both of these, allowing the minimalist, U- shaped device the researchers designed to consist solely of a 400-micrometer diameter core multimode fiber with a silver-coated sensing region. In a proof-of-concept version of the sensor, Bremer carefully excised the polymer coating from a 10-millimeter segment of the optics cable to expose the bare 400- micrometer diameter glass fiber core. The segment is cleaned, subjected it to a silver- coating process, added a small well in which to pour the solutions being observed, and polished both ends of the fiber to 45° angled faces. They were then adhered to the phone's case and, thus, to its LED and camera, the latter of which was affixed with a diffraction grating to separate the light beam into an emission spectrum. In subsequent experiments, the device's sensitivity was tested using various concentrations of glycerol, and the team confirmed it was on par with current equipment, at a fraction of the cost and size.

XII. CONCLUSION

Major fundamental and technological advances have been made for enhancing the capabilities and improving the reliability of glucose measuring devices. Such intensive activity has been attributed to the tremendous economic prospects and fascinating research opportunities associated with glucose monitoring. The glucose biosensor has been widely used as a clinical indicator of diabetes. The calibration of the devices and quality control should be performed on a regular basis according to the manufacturer's instructions. Some factors are User-dependent which may affect the data quality and treatment.

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