UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS OF FIBER OPTIC CONCEPT FOR GLUCOSE SENSOR DEVELOPMENT

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronics Engineering Technology (Telecommunications) (Hons.)

by

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I hereby, declared this report entitled **"ANALYSIS OF FIBER OPTIC CONCEPT FOR GLUCOSE SENSOR DEVELOPMENT"** is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor's Degree in Electronics Engineering Technology (Telecommunications)(Hons.) The members of the supervisory committee are as follow:

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ABSTRACT

Projek ini bertajuk ' ANALISIS FIBER OPTIK KONSEP UNTUK MENDALAMI SENSOR GLUKOSA adalah untuk menyiasat sifat-sifat kimia bahan yang menghasilkan sebagai kepentingan pengesanan glukosa untuk kedua-dua pesakit kencing manis dan bukan kencing manis terus meningkat, terdapat keperluan untuk lebih maju teknologi glukosa- sensing. Khususnya, dalam vivo sensor glukosa diperlukan yang mempamerkan ketepatan yang tinggi semasa mengendalikan secara berterusan untuk tempoh yang agak panjang. Pembangunan sensor itu telah terjejas, ketepatan yang rendah dan sensor hanyut menjadi masalah utama dalam vivo persekitaran, terutamanya berasaskan enzim- sensor glukosa elektrokimia. Laporan kertas ini mengenai penggunaan novel , mengikat berasaskan polipeptida , pendarfluor, sistem penderiaan glukosa yang menjanjikan untuk mengatasi banyak kelemahan sistem berasaskan enzim- sambil menunjukkan potensi untuk ketepatan yang tinggi, terutamanya di peringkat hipoglisemik. Fluorescently dilabel elemen polipeptida pengiktirafan glukosa telah bergerak dalam matriks polyacrylamide hidrogel diletakkan di hujung gentian optik untuk merealisasikan peranti glukosa -sensing berterusan ke arah dalam vivo aplikasi. Dalam perkataan pedas pengesahan telah dilakukan di kedua-dua penyelesaian buffered dan darah keseluruhan untuk mencirikan parameter sensor seperti kepekaan dan masa tindak balas. Ujian menunjukkan bahawa reagen kurang sistem glukosa -sensing berasaskan polipeptida - mempunyai kepekaan melampau dalam tahap hipoglisemik sambil memberikan ketepatan yang tinggi di seluruh rangkaian glukosa keseluruhan manusia fisiologi . Selain itu, alat tersebut telah ditunjukkan untuk berfungsi pada suhu fisiologi (viz. , 37 ◦ C) dan dipaparkan pemilihan tinggi untuk glukosa tanpa gangguan daripada gula lain (viz. , fruktosa). Ini merupakan laporan pertama melaksanakan mengikat glukosa bergerak protein seperti elemen dalam peranti penderiaan untuk pemantauan glukosa yang berterusan, dan menunjukkan bukti -of- konsep sebagai alternatif yang sangat baik untuk masalah mengatasi ofcurrent jangka panjang , berterusan glukosa penderiaan technologies.

ABSTRACT

This project entitled 'ANALYSIS OF FIBER OPTIC CONCEPT FOR GLUCOSE SENSOR DEVELOPMENT' is to investigate the chemical properties of the material that produce as the importance of blood-glucose control for both diabetic and non-diabetic patients continues to increase, there is a need for more advanced glucose-sensing technologies. In particular, an in vivo glucose sensor is needed that exhibits high accuracy when operating in a continuous manner for a relatively long period of time. Development of such sensors has been hampered, as low accuracy and sensor drift become major problems with in vivo environments, especially for enzyme-based electrochemical glucose sensors. This paper reports on the use of a novel, binding polypeptide-based, fluorescent, glucose sensing system that promises to overcome many drawbacks of an enzyme-based system while showing the potential for high accuracy, especially at hypoglycemic levels. Fluorescently labeled glucose recognition polypeptide elements were immobilized in a polyacrylamide hydrogel matrix placed on the tip of an optical fiber to realize a continuous glucose-sensing device towards in vivo applications. In vitriol validation was performed in both buffered solutions and whole blood to characterize sensor parameters such as sensitivity and response time. Testing demonstrated that the reagent less polypeptide-based glucose-sensing system has extreme sensitivity in the hypoglycemic levels while providing high precision across the entire human physiologic glucose range. Additionally,the sensor was shown to function at physiologic temperature (viz., 37◦C) and displayed high selectivity for glucose without interference from other sugars (viz., fructose).This represents the first report of implementing immobilized glucose binding protein-like elements in a sensing device for continuous glucose monitoring, and establishes proof-of-concept as an excellent alternative to overcoming problems of current long-term, continuous glucose-sensing technologies.

DEDICATION

This research was dedicated to:

My Parent:

RAMLI BIN ISMAIL

SITI AJAR BTE ABDUL RAHMAN

Who are always praying and support for my success, always be my side, struggle to give me enough education and always loving me with full of their hearts.

Special thanks to my siblings & friend from 3BETT

Who are always support me in everything that I did, giving me meaningful advice and also help me through the easiness and hardness time.

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I would like take this opportunity to express my profound gratitude and deep regards to my supervisor for the Final Year Project I & II, Mr MD Ashadi Bin MD Johari , for his exemplary guidance, monitoring and constant encouragement throughout the course of this thesis. The blessing, help and guidance given by him time to time shall carry me a long way in the journey of life on which I am about to embark.

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LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

SF	-	Silica Fiber
ZnO	-	Zinc Oxide
OSA	-	Optical Spectrum Analyzer
B. C.	-	Before century
m	-	meters
cm	-	centimetres
mm	-	millimetres
%	-	percentage
K	-	temperature
MPa	-	Mega Pascal
GPa	-	Giga Pascal
J	-	Joule
NF	-	Natural Fibre
RP	-	Rapid Prototyping
UV	-	Ultraviolet
SLA	-	Stereolithography Apparatus
3D	-	3 dimensional
SLS	-	Selective Laser Sintering
3DP	-	Three Dimensional Printing
LOM	-	Laminated Object Manufacturing
FDM	-	Fused Deposition Modelling
CVD	-	Chemical Vapor Disposition
SCS	-	Silicon carbide fibers
W	-	Tungsten

CHAPTER 1
INTRODUCTION

1.1 Background

Nowadays , much biosensor research in industry and academia has focused on the development of robust glucose sensors, with a resulting abundance of reported technologies and medical applications . The currently available and successful point-of-care (POC) handheld glucometers are electrochemical-based and commonly rely on either glucose oxidase (GOX) or glucose dehydrogenase(GDH) enzymes. However, these devices have significant drawbacks.In practice, their use is burdensome and often not accurate nor specific, especially in hospital environments, as they result in inconsistent readings with errors that can exceed 20% . These sensors also have severe limitations in differentiating between low-normal glucose levels and hypoglycemia, and some suffer specificity issues as highlighted by the FDA's warning regarding POC meters .

In particular, a possible interfering sugar is fructose, and can fluctuate in high concentrations depending on, for example, a patient's diet, which may consist of high amounts of fruit juices.The main motivator of glucose sensor research and development is the world's large and growing diabetic population, with an estimated 350 million people worldwide suffering from diabetes mellitus by 2025[1] . In addition, studies have indicated the need for blood-glucose control of all in-hospital patients (including non-diabetics), especially those in critical conditions . By controlling blood-glucose levels within a narrow range, a concept known as tight glycemic control (TGC), studies have demonstrated decreases in morbidity, mortality, time of hospital stay, and other complications for patients in critical care conditions .

Some recent studies have suggested that attempting TGC is difficult and is associated with increased risks of hypoglycemia and related complications by reading these reports in detail, one realizes this is in large part due to the lack of an accurate and reliable continuous glucose-sensing technology.

In the majority of these “negative” studies, clinicians attempted TGC with the same inadequate handheld POC glucometers discussed above, with measurements taken infrequently, such as only once per hour the infrequent measurements and large sensing errors make TGC difficult.Despite disagreements of how tightly blood glucose should be controlled or within which range, it has been generally accepted that blood-glucose control is important, and that the benefits of TGC can only be realized if such efforts do not increase the risk of hypoglycemia. This further underscores the need for accurate and reliable continuous glucose monitoring (CGM). There are arguably no CGM devices on the market capable of maintaining the required accuracy over time. Of note, however, are Dexcom’s SEVEN+ and Medtronic’s MiniMed Guardian CGM systems, which measure subcutaneous glucose electrochemically in interstitial fluid[2]. Substantial sensor drift and poor reliability have hindered FDA approval as stand-alone glucose measurement devices, as they are approved only for adjunctive use . Thus,there remains a need for better, more advanced glucose-sensing technologies that can meet today’s continuous in vivo applications and healthcare requirements.

There are many alternative technologies under development that may overcome problems of the common electrochemical based enzyme glucose-sensing systems discussed above. Some of these sensing methods include near infrared (NIR) spectroscopy,optical coherence tomography (OCT), and fluorescence-based systems. Specific examples of fluorescence methods include fluorescent boronic acid-based sensors, and fluorescently labeled binding proteins and elements, the later of which are the focus of the work presented here. Other common fluorescence based glucose-sensing approaches involve the use of Concanavalin A (ConA). Indeed, in the field of fiber-optic based glucose sensors much progress has been made by adopting ConA in various forms onto fiber-optic sensors .More extensive overviews of various glucose-sensing technologies can be found in the literature.

1.2 Problem Statement

In general for nowadays, In current situation , the way to detect a glucose is by used chemical reaction on various type of blood. Fiber optic will be used to replace chemical usage to detect glucose level in blood.Development of such sensors has been hampered , as low accuracy and sensor drift become major problem with in environments , especially for enzyme - based electrochemical glucose sensors to detect the important of blood glucose control in body . However , in practice , especially in hospital environments , as the result in inconsistent reading with error that can exceed 20 % .

1.3 Work Scope Of Research

The scope to make work done has to been list down on what are going to be done first especially to save the time and cost . There are :

a) Understanding the concept of fiber optic .

b) Studying detailed about glucose characteristic.

c) Collect the data and analyze the immobilized glucose - sensing .

d) Designing the specification of prototype fiber optic sensor .

e) Simulation by spectrophotometer to test the devices.

1.4 Research Objective

a) To implement of fiber optic concept and applying the technologist into development glucose - sensing .

b) To build the sensor device that more accurate and consistent reading .

c) To understand about photonic sensor implementation.

1.5 Project Limitation

The limitations of this project are:

a) The light source must be touched by the blood to indicate the type of glucose.

b) The soft object wills hard to detect must be followed by the sensor.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The literature review is the where the knowledge and ideas that have been established on a topic is defined. The discussion on the problem issue, research objectives and the methodology used are supported by the established knowledge that reviewed from books, journals, articles and related website. Chapter 2 of this project report provided the introduction to the clamp and Work holding devices which include the function of Fiber Optic. Furthermore, this chapter has a review of the material properties which are the materials used to produce the laser sensor by using light source process. The types of the chemical process consist in this review and concerned with the permanent mould where the metal mould material is used and the fiber behaviour of light source. There are several types of rapid prototyping technique for pattern making is reviewed in this chapter. Besides that, this chapter review of the types of testing will be used for this project.

2.2 Fiber

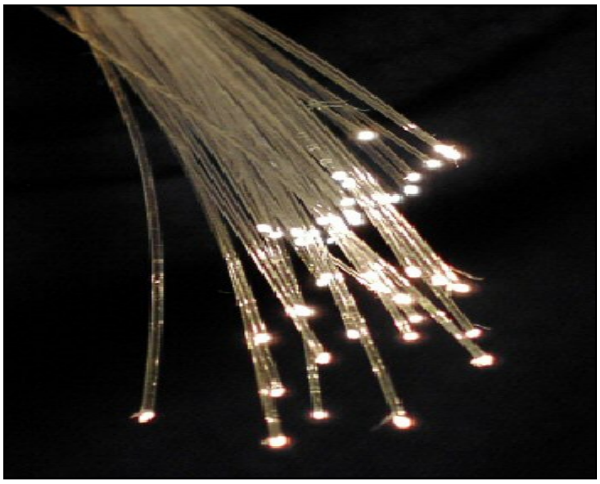

Figure 2.2 : Fiber Optic

An optical fiber (Figure 2.2) is a thin, flexible, transparent fiber that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so they can be used to carry images, thus allowing viewing in tight spaces. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers[3].Optical fiber typically consists of a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Fibers which support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those which can only support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a larger core diameter, and are used for short-distance communication links and for applications where high power must be transmitted.[6]

Otto S. Wolfbeis is Professor of Analytical Chemistry at the University of Regensburg, Germany. He has authored many papers and reviews on optical (fiber) chemical sensors, fluorescence spectroscopy, and fluorescent probes and has edited a book on Fiber Optic Chemical Sensors and Biosensors. He acts as the editor of a book series on New Methods and Applications of Fluorescence Spectroscopy, as the chairman of the steering committees of the biannual conferences on Optical Chemical Sensors (Europtode) and on Methods and Applications of Fluorescence (MAF), respectively. His research interests are in optical chemical sensing and biosensing, in the design of novel schemes in analytical fluorescence spectroscopy, in fluorescent probes and labels, in biosensors based on thin gold films and molecular imprints, in the design of advanced materials for use in (bio)chemical sensing, and in biomedical and applications of such sensors and analytical schemes.

2.2.1 Fiber Optic

The telecommunications industry is the heaviest user of Fiber Optic technology. The deployment of fiber throughout the telecommunication network began in the 1980s. One of the main reason and advantage of using fiber in telecommunication network is the potential of fiber to "future proof" the network. The term "future proof" is coined because of fiber's theoretical unlimited bandwidth.

Bandwidth is a measurement of data carrying capacity of a data transport media such as fiber. A higher bandwidth media will enable greater data transmission capacity. Previously, telecommunication network operators deploy copper as their data transmission network. However, copper has tight limitation in both transmission distance and bandwidth, thus fiber is the perfect substitute as it is far more superior in both aspects. Other benefit of Optical Fiber includes: