CHARACTERIZATION OF LIMONENE CONCENTRATION BASED ON TAPERED POLYMER OPTICAL FIBER

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

This thesis is dedicated to my beloved mother, Puan Mukinah binti Sujak whom never doubted my capability to achieve things and being one of the backbone of my studies. I also would like to express my gratitude towards my siblings especially my sister who always supported me either financially or emotionally, all the way to keep me on track.

ABSTRACT

The research will demonstrate the capability of an optical sensing technology to measure limonene concentration, which is one of the possible biomarkers for early liver disease detection, and make it more dependable in industry-based applications. Using the Polymer Optical Fiber (POF) sensor, the change in output voltage against varied dimensions of tapered POF, different LED light sources (RGB), and variations in limonene concentration levels were detected. The difference in limonene concentrations indicates different level of liver health in a human body. The developed sensor device consists of an RGB light emitting diode (LED) and a photodiode that acts as a light source and detector for POF. The receiving circuit and Arduino platform were used for signal amplification and processing. The POF was tapered to four different diameters to test the sensitivity of the sensor (0.70mm, 0.65mm, 0.60mm, and 0.55mm). UV Visible Spectroscopy was applied to study the absorption of light, which based on the absorption of ultraviolet or visible light by a substance. Overall, the result from this research shows that the 0.055mm diameter of tapered POF with Green LED as the source of light, recorded the highest sensitivity and linearity. As for the UV-Vis, the sample with 100% limonene concentration obtained the highest absorption of light, with the least rate of light transmission.

ABSTRAK

Penyelidikan ini akan menunjukkan keupayaan teknologi penderiaan optik untuk mengukur kepekatan limonene, yang merupakan salah satu biomarker yang mungkin untuk pengesanan penyakit hati awal, dan menjadikannya lebih dipercayai dalam aplikasi berasaskan industri. Menggunakan sensor Gentian Optik Polimer (POF), perubahan voltan output terhadap pelbagai dimensi POF tirus, sumber cahaya LED yang berbeza (RGB), dan variasi dalam tahap kepekatan limonin dikesan. Perbezaan kepekatan limonene menunjukkan tahap kesihatan hati yang berbeza dalam tubuh manusia. Peranti sensor yang dibangunkan terdiri daripada diod pemancar cahaya RGB (LED) dan fotodiod yang bertindak sebagai sumber cahaya dan pengesan untuk POF. POF diruncing kepada lima diameter yang berbeza untuk menguji sensitiviti sensor (0.70mm, 0.65mm, 0.60mm dan 0.55mm). UV Spectroskopi digunakan untuk mengkaji penyerapan cahaya, yang berdasarkan penyerapan cahaya ultraviolet atau cahaya yang kelihatan oleh bahan. Hasil daripada penyelidikan ini menunjukkan bahawa diameter 0.055mm POF tirus dengan LED Hijau sebagai sumber cahaya, mencatatkan sensitiviti dan lineariti tertinggi. Bagi UV-Vis, sampel dengan kepekatan limonene 100% memperoleh penyerapan cahaya tertinggi, dengan kadar penghantaran cahaya yang paling sedikit.

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LIST OF SYMBOLS AND ABBREVIATIONS

POF	:	Polymer Optical Fiber
NAFLD	:	Non-Alcohol related Fatty Liver Disease
WHO	:	World Health Organization
HE	:	Hepatic Encephalopathy
HCC	:	Hepatocellular Carcinoma
RGB	:	Red Green Blue
LED	:	Light Emitting Diode
SHM	:	Structural Health Monitoring
SMF	:	Single Mode Optical Fiber
MMF	:	Multimode Optical Fiber
PMMA	:	Polymethylmethacrylate
NIR-PIT	:	Near-InfraRed PhotoImmunoTherapy
UV-Vis	:	Ultra Violet Visible
LCD	:	Liquid-Crystal Display
EW	:	Evanescent Wave
RI	:	Refractive Index
PCB	:	Printed Circuit Board
%Li	:	Percentage of Limonene
IoT	:	Internet of Things

LUMO : Lowest Unoccupied Molecular Orbital

HUMO : Highest Unoccupied Molecular Orbital

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Non-alcohol related fatty liver disease (NAFLD) is likely to overtake alcohol as the leading causes of liver disease in the next few years. The chemicals build up in our bodies affecting our liver and some other internal organs, which can eventually lead to liver damage [1]. When the liver is damaged, fatty or inflamed, it cannot work as efficiently as a healthy liver. It cannot process toxins and eliminate toxins from our body. It also burns less excess fat and cholesterol, leading to even more fatty deposits in the liver and weight gain [2] The statistics from WHO in 2017 stated that the death due to liver diseases has reached 2286 which contributed to 1.65% from the total deaths in Malaysia. As the liver disease is difficult to detect, researchers discovered that the limonene compound is greater in patients with liver disease than in healthy ones [3].

Therefore, a non-invasive and low cost sensor is proposed in this project for limonene characterization.

1.2 Project Background

The limitation of existing liver disease biomarkers is their limited application owing to their lack of simplicity and sensitivity. As a result, a simple, noninvasive, and low-cost way of monitoring the course of liver disease is needed. The research will demonstrate the capability of an optical sensing technology to measure limonene concentration, which is one of the possible biomarkers for early liver disease detection, and make it more dependable in industry-based applications. Using the POF sensor, the change in output voltage against varied dimensions of tapered POF, different LED light sources (RGB), and variations in limonene concentration levels were detected. The difference in limonene concentrations indicates different level of liver health in a human body.

1.3 Problem Statement

Liver diseases are mostly asymptomatic which means that until the person is tested, it is difficult to detect the symptoms. Some tests to diagnose the diseases are through blood test, liver ultrasound and liver biopsies. Currently, there is no set of signals that specifically warns beforehand about a faulty liver. Some patients do experience symptoms that related to liver problem but was often disregarded as normal occurrence. Hence, the majority of instances of liver disease are detected late, with existing techniques relying on invasive biopsy or vulnerable lab-based antibody technology. Other than that, the commonly used method detection is mainly conducted in blood which needed to use expensive enzymes enzymatic reactions. Besides, other existing biomarkers for detecting liver disease, such as isoprene, acetone, and ethanol, are inadequately specific since they might be biomarkers for other disorders or originate from a number of normal metabolic processes.

1.4 Project Objective

This project aims to characterize limonene concentration based on polymer optical POF. This aim can be achieved by the following objective:

i. To design the electrical to optical converter circuit for the LED light source and photo detector of the POF sensor.

ii. To analyze experimentally the performance of POF sensor with different concentration of limonene.

1.5 Scope of the Project

For this project, different wavelengths of RGB LED light source are used. Red has the longest wavelength at 620nm-750nm. Green has a wavelength of 495nm-570nm, which is between Blue and Red, while Blue has the shortest wavelength of 450nm-495nm. The Polymer Optic Sensor is formed in five different diameters. The diameters are 0.70mm, 0.65mm, 0.60mm, and 0.55mm. In addition, different limonene concentrations starting from 20% limonene, 40% limonene, 60% limonene, 80% limonene and 100% limonene are used to get the output voltage from the electrical to optical converter circuit. The solutions are mixed with Hexane (example: 20% Limonene, 80% Hexane).

1.6 Environment and Sustainability

This project can significantly impact health professionals, especially doctors and physicians which will allow a real time monitoring of concentration level of limonene for patients who suffer with liver diseases. With the succession of this project, an early detection device which will be produced can reduce the death rate among patients as a treatment plan can be conducted instantly. Besides, it will be cost effective to use POF as it is affordable and has been dubbed as consumer optical fiber. Compared to other electronic sensors, optical fiber provides less harm to the environment with its low installation cost.