UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FIBER OPTIC SENSOR DEVELOPMENT ON LIQUID CETIRIZINE DETECTION FOR PHARMACEUTICAL INDUSTRY

This report submitted in accordance with requirements of the University Technical Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronic Engineering Technology (Telecommunication) (Hons.)

By

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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 of Electronic Engineering Technology (Telecommunication) (Hons.). The member of the supervisory is as follow:

…….

(Rahaini Binti Mohd Said)

ABSTRACT

Fiber optic sensor for Liquid Cetirizine detection is a technology that sensing liquid using fiber optic cable. This research was made to develop a sensor that can detect parameter in a liquid. This sensor is examined in 6 different percentage of concentration which is 50%, 60%, 70%, 80%, 90% and 100%, and 4 different wavelength which is 850nm, 1300nm, 1310nm and 1550nm are examined in each of the concentration. The fiber optic sensor is immersed in the Cetirizine concentration within 1 hour and data was recorded in every 5 minutes. This step was repeated by changing the concentration value of Cetirizine and wavelength of the light source. Finally, the concentration of Cetirizine liquid will influence the fiber optic sensor and in the fiber itself will experience subtle changes of its parameters.

ABSTRAK

Sensor fiber optik adalah teknologi yang menggunakan kabel gentian optik untuk mengesan cecair Cetirizine. Kajian ini dibuat untuk mencipta sebuah sensor yang dapat mengesan parameter dalam cecair. Sensor ini dikaji dalam 6 peratusan kepekatan yang berbeza iaitu 50%, 60%, 70%, 80%, 90% dan 100%, dan 4 *wavelength* yang berbeza iaitu 850nm, 1300nm, 1310nm dan 1550nm yang turut dikaji dalam setiap kepekatan. Sensor gentian optik direndam dalam cecair Cetirizine mengikut kepekatan dalam masa 1 jam dan data yang diperolehi akan dicatatkan setiap 5 minit. Langkah ini diulang dengan menukar nilai kepekatan Cetirizine dan sumber cahaya *wavelength* yang lain. Akhirnya, kepekatan cecair Cetirizine akan memberi kesan kepada sensor gentian optik lalu data yang diperolehi akan menunjukkan perubahan bacaan pada keluarannya.

DEDICATIONS

This report is dedicated to my beloved parents Mr. Doraisingam and Mrs. Sakti Rani, to my supervisor Madam Rahaini Binti Mohd Said, kind lecturers and to all friends for their Love, Sacrifice, Encouragement, and Best Wishes.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

L.S	-	Light Source
dB	-	Decibels
ASE	-	Amplified Spontaneous Emission
OSA	-	Optical Spectrum Analyzer
FOS	-	Fiber Optic Sensor
pH	-	Power of Hydrogen
RF	-	Radio Frequency
EM	-	Electromagnetic
pO_2	-	Partial Pressure of Oxygen
pCO_2	-	Partial Pressure of Carbon Dioxide
O_2	-	Oxygen
Sn2	-	Slush Nitrogen
HCl	-	Hydrochloric Acid
CT	-	Computed Tomography
MRI	-	Magnetic Resonance Imaging
SPECT	-	Single-photon Emission Computed Tomography
PET	-	Positron Emission Tomography
EFPI	-	Extrinsic Fabry-Perot Interferometers
FBG	-	Fiber Bragg Gratings
MIS	-	Minimally Invasive Surgery
IPA	-	Isopropyl Alcohol
COD	-	Coefficient of Determination
λ	-	Wavelength of Light (lambda)

CHAPTER 1
INTRODUCTION

1.0 Overview

In this part of chapter, project background will be discussed briefly to understand the concept of Fiber Optic sensor. This chapter also includes the explanations for problem statement, objectives and scope of this project.

1.1 Project Background

Fiber optic is a transparent flexible fiber made by silica glass or plastic that has slightly thicker diameter than a human hair. Fiber optics are widely used in telecommunication field due to its ability in sending information in high speed data rate. In general, fiber optic uses light source as a medium to transmit data from one end to another end. This is the main factor why telecommunication industries use fiber optics as a communication system. In addition, fiber optics are also immune to an electromagnetic interference that makes fiber optic better instead of using metal wires. Furthermore, fiber optics are guaranteed has small amounts of data losses that makes it more reliable and its preciseness is one of the reason fiber optics were used in sensor applications.

Fiber optics sensor are fiber-based devices which used as sensing mechanism for sensing typical temperature, quantity, pressure or concentrations of chemical species. The operation of fiber optic sensor process is operated when light from a laser is sent through a fiber optic and in the fiber itself will experience subtle changes of its parameters and then it will reach a detector arrangement where it measures all these changes. Fiber optic sensors are more ideal to use compared to other type of sensors due to its chemically passive materials which it do not contaminate by their surroundings environment and insensitive to corrosion, and also the abilities to operate in high temperature.

By using fiber optic as a sensor or in other words called as Fiber Optic Sensor, this project will focus on determining the effectiveness of fiber optic sensor towards the detection of concentration level in a cetirizine liquid. Due to its advantages such as accuracy, simplicity of design, low cost fabrication and flexible dynamic range makes Fiber Optic Sensor more unique and beneficial for real-field applications. Therefore, the purpose of this project is to analyse the sensitivity of Fiber Optic Sensor towards the concentration level of cetirizine liquid.

The implementation of fiber optics for detecting applications is one of the advance technology that worlds have today. Fiber Optic Sensors (FOS) are widely used in Civil Engineering, Chemical Engineering, and Aeronautics, but now thru the evolution, it is now expending to Biotechnology, Medicine and Pharmaceutical Industry.

1.2 Objectives

The objectives of this project are stated as below:

1) To study Fiber Optic Sensor operation.
2) To develop Fiber Optic Sensor on liquid cetirizine detection.
3) To analyse the performance of Fiber Optic Sensor.

1.3 Problem Statement

There are various types of sensors that has been developed these days for different type of use. Nowadays, humans are concern on their health to live a healthy lifestyle especially the youngster. But, the question is how they need to ensure that they are in healthy lifestyle? A balance diet, exercising would make human healthier but do they realise taking a medicine also is one of the important element they should aware. When taking any medicine, human need to aware the medicine concentration or dosage level that suitable for them. Lack of awareness will lead to allergies or overdose. Common method of measuring dosage level is by using spoon or cup as a measuring device. But these measuring devices are not accurate to measure the dosage level. Therefore, a fiber optic sensor is develop to study the effectiveness or sensitivity towards cetirizine liquid where in future this fiber optic sensor can help

pharmaceutical industries to detect the most suitable dosage or concentration medicine level that a patient should take especially children age below 12 year's old.

1.4 Project Scope

A coordinated scope of work need to be done in order to develop a fiber optic sensor. By determining the scope of this project, it is believe that the objectives can be achieve. Below are the scopes of work in this project:

a) Study the compatibility of fiber optic as a sensor on the concentration of cetirizine liquid.
b) Analyzing the effectiveness of fiber optic as sensor.
c) Analysis will be carried by varying the concentration parameters of cetirizine liquid in order to obtain the experiment results to differentiate with the theoretical results.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Literature review need to be done at the start before proceeding with the project. It is important so that the current knowledge on the project will be more extensive. In other words, it is actually the reading of the works of others before commencing on our own work. Broader knowledge will have better understanding if proper literature review are made about the project. Literature review can be found in primary sources, secondary sources and general sources. Example of sources are books, journals, newspaper and magazines. This chapter will study some projects that related to fiber optic sensor on liquid cetirizine concentration detections.

2.1 Fiber Optic

Based on the understanding of a study, a fiber optic is a flexible, transparent fiber that made of glass or solid ultrapure plastic rode that will carry light along the core of fiber optic with the help of total internal reflections. An optical fiber consists of core, cladding, coating or buffer, strengthening fibers and cable jacket as shown in Figure 2.1a below.

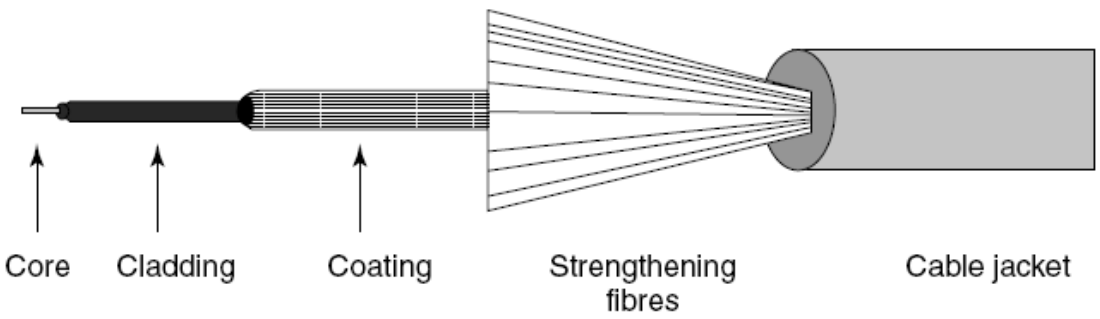

Figure 2.1a: Anatomy of a fiber optic.

The purpose of special coating which applied to the outside of cladding is to seal and preserve the strength of the fiber and also protect against moisture to reduce stress corrosion. The function of claddings is to reflect light back into the core. This situation will help reduce losses of transferred data. Besides that, the function of outer layer which is the cable jacket is to protect from moisture and also mechanical damage.

There are 3 types of fiber optic, which are the Plastic Core and Cladding, Glass Core and Plastic Cladding and Glass Core and Cladding. The advantage of using plastic fibers are more flexible but the problem is it produce higher attenuation than glass fibers. The best type of fiber optic to use is the Glass Core and Cladding where it offer better light propagation and easier termination. However, Glass Core and Plastic Cladding have less affected to external radiation.

There are two types of fiber optic cables, they are named as the multi-mode fiber optic cable and single-mode fiber optic cable. A **single-mode** fiber optic cable is a single stand of a glass or plastic fiber where normally have a diameter of 8.3 to 10 microns that allows only one light to propagate. In other words, single-mode fiber optic relatively have narrow diameter area through which only single mode can propagate typically 1310 or 1550nm. Single-mode fiber carries greater bandwidth than multi-mode fiber, but it require a narrow spectral width of a light source. One of the main advantage of using single-mode fiber is the distance allowance where it allows 50 times longer distance with a higher transmission rate than multi-mode fiber optic. However, single-mode fiber will costs more due to only single light can propagate in a time. As shown in Figure 2.1b and Figure 2.1c, single-mode fiber optic has a smaller core diameter than multi-mode fiber optic. The small core diameter and single light wave will practically eliminate any distortion that might result from overlapping light pulses, hence will provide least signal attenuation and higher transmission speed.

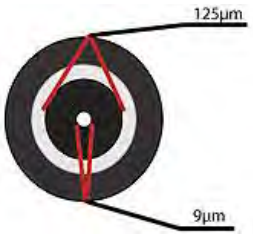

Figure 2.1b: Single-mode fiber optic.

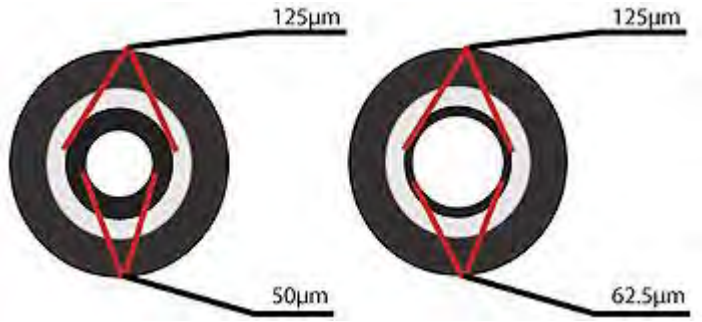

Figure 2.1c: Multi-mode fiber optic.

Multi-mode fiber optic cable is made of glass material fibers, commonly with diameter in the range of 50 to 100 microns. The most common size fiber optic diameter that is used today is 62.5 microns. Using a multi-mode fiber optic allows higher bandwidth at high speed over average distances. However, in long distance, multiple paths of lights will cause signal distortion at the receiving edge, which leads to an unclear and imperfect data transmission.

The main difference between single-mode and multi-mode fiber optic is that the multi-mode has larger core diameter typically between 50 to 100 micrometers. Due to its large core and also the probability of large numerical aperture, multi-mode fiber optic has a higher light-gathering size than a single-mode fiber optic cable. Practically, larger core size simplifies connection and allows to use lower cost electronics equipment such as light-emitting diodes (LED's). Nevertheless, compared to a single-mode fiber optic, the multi-mode fiber optic bandwidth distance is limited.

Single-mode fibers are usually used in high precision scientific experimentation because limiting the light to only one propagation mode enables it to focus more. The colour of a fiber optic jacket sometimes used to differentiate single-mode cables from multi-mode ones. Throughout the studies, the TIA-598C standard for non-military applications recommends that the yellow jacket is used for single-mode fiber cable and aqua or orange colour is for multi-mode fiber cable which depends on the type [1].

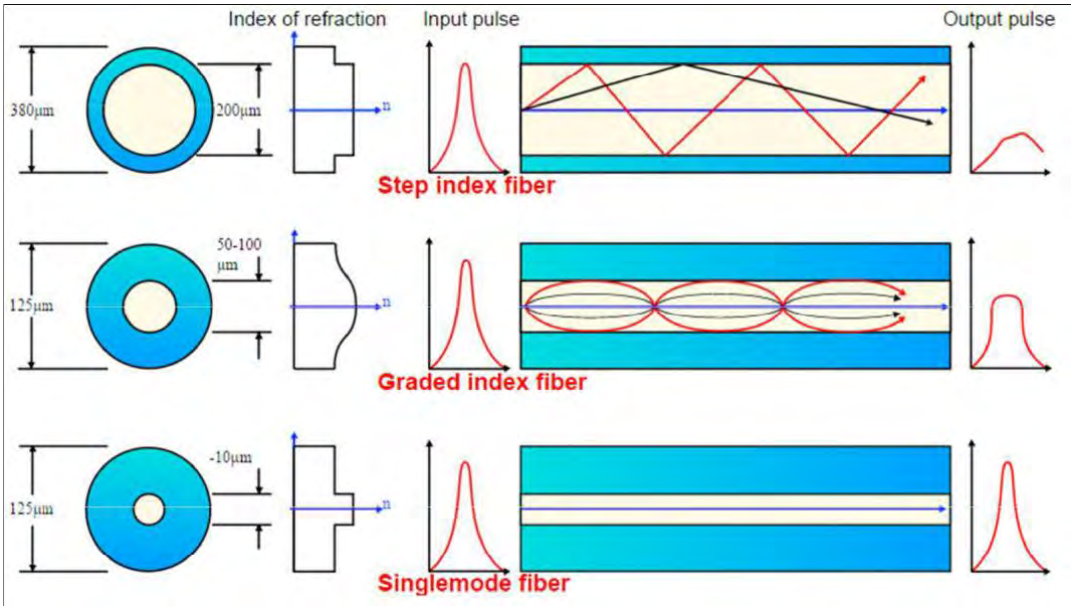

Figure 2.1d: Light propagation in 3 different fiber cables.

Figure 2.1d shows light propagation in 3 different fiber cables. Two of it is a type in a multi-mode fiber optic cable, which is the step-index fiber and graded-index fiber. A **step-index fiber** has a large core, therefore some light rays may travel in a direct route, while others in the shape of zigzag as they reflect off the cladding. This every other paths will lead to different groups of light rays to arrive separately at the receiving point. This behavior will cause the pulse begins to scatter and losing its shape. The necessity of leaving a space between pulses is to avoid overlapping limits of information that can be sent. This type of fiber optic is suitable for short distance transmission.

Graded-index fiber consists a core where the refractive index decreases gradually from the middle axis out towards the cladding. High refractive index at the middle point makes the light rays moving down the axis at slower pace than those near the cladding. Rather than in the shape of zigzag, lights in the core bends helically in the graded-index fiber where it reduce its travel distance. This type of fiber optic cable is suitable for local-area networks.