# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## A DEVELOPMENT OF FIBRE OPTIC SENSOR FOR DETECTING ALCOHOL (ETHANOL) LEVEL IN PERFUME

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunications) with Honours.

By

**MUHAMAD ANWAR BIN MD KURDI**

**B071310063**

FACULTY OF ENGINEERING TECHNOLOGY

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

TAJUK: **A Development of Fiber Optic Sensor For Detecting Alcohol Level In Perfume (Ethanol)**

SESI PENGAJIAN: **2016/17 Semester 1**

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I hereby, declared this report entitled "Fiber Optic Sensor for Sodium Chloride Concentration" is the results of my own research except as cited in references.



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**Date** : ..........................

**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 Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

……………………………

(Md Ashadi bin Md Johari)

# ABSTRAK

“*Penghasilan pengesan gentian optik untuk mengesan tahap alkohol (ethanol) dalam minyak wangi*” adalah dicipta untuk mengesan sukatan alkohol di dalam minyak wangi. Projek ini memberi tumpuan kepada beberapa janama minyak wangi yang berada di pasaran. Dengan meletakkan sample minyak wangi pada fiber optik tersebut, keputusan kajian akan diperolehi. Hasil kajian ini akan membandingkan beberapa jenama minyak wangi yang digunakan sebagai bahan kajian. Diharapkan hasil kajian ini dapat membantu pengguna mengenalpasti jenama minyak wangi yang mempunyai sukatan alkohol yang tinggi dan rendah.

# ABSTRACT

***"A DEVELOPMENT OF FIBRE OPTIC SENSOR FOR DETECTING ALCOHOL (ETHANOL) LEVEL IN PERFUME"*** was created to measure the alcohol level in perfume. This project focuses on some of the perfume brand that was on the market. By put the sample of perfume at the fiber optic, the result of the experiment will be obtainable. The study will compare several brands of perfume that used as research material. It is hoped that the study will help the user identify the perfume brands that have level of alcohol that are high and low.

# DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time. They also helped me financially and supported throughout finishing this project report

## ACKNOWLEDGEMENT

I would like to thank our at Universiti Teknikal Malaysia Melaka lecturers especially my project supervisor Mr. Md Ashadi Bin Md Johari who really helped me a lot throughout finishing my project. They don’t hesitate to teach me whenever I need help or support.

I also would like to thank my friends and my classmates who really help by giving advice and sharing information in finishing my project.

Lastly, one again I wish to thank everyone that help me in completing my final year project and report successfully.

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# CHAPTER 1

# INTRODUCTION

## 1.0 Background

A fiber optic sensor is a sensor that uses optical fiber either as the sensing element, or as a means of relaying signals from a remote sensor to the electronics that process the signals. Fibers have many uses in remote sensing. Depending on the application, fiber may be used because of its small size, or because no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using light wavelength shift for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer and wavelength shift can be calculated using an instrument implementing optical frequency domain reflectometry.



Fiber optic sensors are also immune to electromagnetic interference, and do not conduct electricity so they can be used in places where there is high voltage electricity or flammable material such as jet fuel. Fiber optic sensors can be designed to withstand high temperatures as well.

## 1.1 Problem Statement

A various kind of sensors has been developed nowadays for different type of usage. For example, a precise and highly sensitive sensor is preferred when it comes to measurement and analyze a chemical substance. For example, to obtain a blood sample in medical laboratory, an accurate and precise acetone concentration technique was used.

In general, the chemical sensors are classified into three parts which is gas, liquid and solid particle. The design of chemical sensor is required appreciation of the needed degree of quantitative reliability.

An electrochemical has been introduced to determine the chemical concentration. For example the acetone (alcohol) rate in perfume. Many perfume products in marker claim that the their product is free alcohol. So that this fiber optic sensor was developed to detect the concentration of acetone in perfume. A few type of perfume will be used as research material.

## 1.2 Objective

The objective of this project is:

i. To study fiber optic sensor operation
ii. To develop fiber optic sensors for detecting alcohol from different brand
iii. To analyze the performance of fiber optic



## 1.3 Limitation

This project would be implemented by optimizing the usage of fiber optic sensor based on beam-through technique. This sensor will be used to detect the concentration of ethanol

## 1.4 Scope

Although there are various techniques used in fiber optic sensor, but the study will cover only on fiber optic sensor beam-through technique. Neither the ethanol physical properties, nor the chemical properties of ethanol will be studied in this paper. Instead, this study will mainly focus on the application of fiber optic as a sensor for the detection of ethanol concentration.

# CHAPTER 2

## LITERATURE REVIEW

### 2.0 Inroduction

This chapter will provide the review of previuos research that is related to this final year project. There are previous researches understanding on the fibre optic sensor, technique used in fibre optic sensor, the role of acetone in the diabetic ketoacidosis, acetone in industrial usage, and the current acetone sensor.

### 2.1 Fibre Optic

An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than wire cables. Fibers are used instead of metal wires because signals travel along them with lesser amounts of loss; in addition, fibers are also immune to electromagnetic interference, a problem from which metal wires suffer excessively. Fibers are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing in confined spaces, as in the case of a fiberscope. Specially designed fibers are also used for a variety of other applications, some of them being fiber optic sensors and fiber lasers.

Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those that support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a wider core diameter and are used for short-distance communication links and for applications where high power must be transmitted.[citation needed] Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft).

An important aspect of a fiber optic communication is that of extension of the fiber optic cables such that the losses brought about by joining two different cables is kept to a minimum. Joining lengths of optical fiber often proves to be more complex than joining electrical wire or cable and involves careful cleaving of the fibers, perfect alignment of the fiber cores, and the splicing of these aligned fiber cores. For applications that demand a permanent connection a mechanical splice which holds the ends of the fibers together mechanically could be used or a fusion splice that uses heat to fuse the ends of the fibers together could be used. Temporary or semi-permanent connections are made by means of specialized optical fiber connectors.The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics



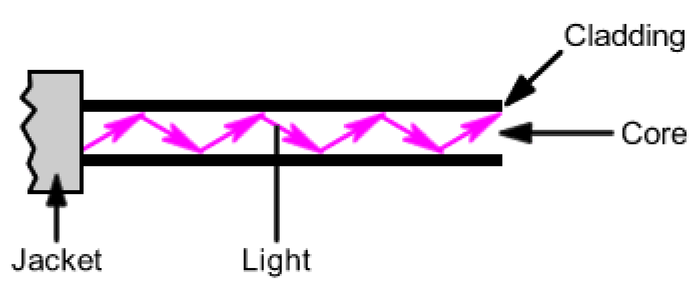


**Figure 2.1:** Light rays incident on the core-cladding interface at the angle greater than the critical angle and trapped inside the fibre core

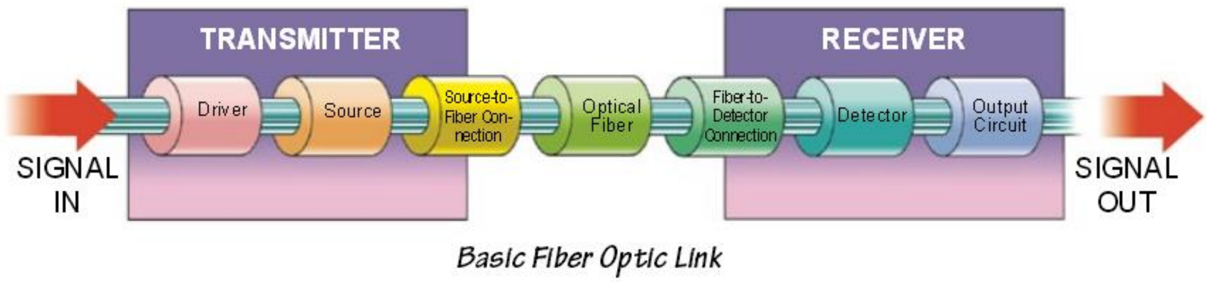


**Figure 2.2:** Basic fiber optic link

### 2.1.1 Principle of operation

An optical fiber is a cylindrical dielectric waveguide (nonconducting waveguide) that transmits light along its axis, by the process of total internal reflection. The fiber consists of a *core* surrounded by a cladding layer, both of which are made of dielectric materials. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The boundary between the core and cladding may either be abrupt, in *step-index fiber*, or gradual, in *graded-index fiber*.



### 2.1.2 Benefits of Fiber Optics

Fiber optic communication systems have many advantages over copper wire-based communication systems. These advantages include:

**1. Long-distance signal transmission**

The low attenuation and superior signal quality of fiber optic communication systems allow communications signals to be transmitted over much longer distances than metallic-based systems without signal regeneration. In 1970, Kapron, Keck, and Maurer (at Corning Glass in USA) were successful in producing silica fibers with a loss of about 17 dB/km at a wavelength of 633 nm.

Since then, the technology has advanced with tremendous rapidity. By 1985 glass fibers were routinely produced with extremely low losses (< 0.2 dB/km). Voice-grade copper systems require in-line signal regeneration every one to two kilometers. In contrast, it is not unusual for communications signals in fiber optic systems to travel over 100 kilometers (km), or about 62 miles, without signal amplification of regeneration.

**2. Large bandwidth, light weight, and small diameter**

Today's applications require an ever-increasing amount of bandwidth. Consequently, it is important to consider the space constraints of many end users. It is commonplace to install new cabling within existing duct systems or conduit. The relatively small diameter and light weight of optical cable make such installations easy and practical, saving valuable conduit space in these environments.

**3. Nonconductive**

Another advantage of optical fibers is their dielectric nature. Since optical fiber has no metallic components, it can be installed in areas with electromagnetic interference (EMI), including radio frequency interference (RFI). Areas with high EMI include utility lines, power-carrying lines, and railroad tracks. All-dielectric cables are also ideal for areas of high lightning-strike incidence.

**4. Immunity to Electromagnetic Interference**

Although fiber optics can solve data communications problems, they are not needed everywhere. Most computer data go over ordinary wires. Most data are sent over short distances at low speed. In ordinary environments, it is not practical to use fiber optics to transmit data between personal computers and printers as it's too costly. Electromagnetic Interference is a common type of noise that originates with one of the basic properties of electromagnetism. Magnetic field lines generate an electrical current as they cut across conductors. The flow of electrons in a conductor generates a magnetic field that changes with the current flow. Electromagnetic Interference does occur in coaxial cables, since current does cut across the conductor. Fiber optics are immune to this EMI since signals are transmitted as light instead of current. Thus, they can carry signals through places where EMI would block transmission.

**5. Data Security**

Magnetic fields and current induction work in two ways. They don't just generate noise in signal carrying conductors; they also let the information on the conductor to be leaked out. Fluctuations in the induced magnetic field outside a conductor carry the same information as the current passing through the conductor. Shielding the wire, as in coaxial cables can reduce the problem, but sometimes shielding can allow enough signal leak to allow tapping, which is exactly what we wouldn't want.

There are no radiated magnetic fields around optical fibers; the electromagnetic fields are confined within the fiber. That makes it impossible to tap the signal being transmitted through a fiber without cutting into the fiber. Since fiber optics do not radiate electromagnetic energy, emissions cannot be intercepted and physically tapping the fiber takes great skill to do undetected. Thus, the fiber is the most secure medium available for carrying sensitive data.



**6. Non Conductive Cables**

Metal cables can encounter other signal transmission problems because of subtle variations in electrical potential. Electronic designers assume that ground is a uniform potential. That is reasonable if ground is a single metal chassis, and it's not too bad if ground is a good conductor that extends through a small building. However, the nominal ground potential can differ by several volts if cables run between different buildings or sometimes even different parts of the same building.

Signal levels in semiconductor circuits are just a few volts, creating a problem known as ground loop. When the difference in ground potential at two ends of a wire gets comparable to the signal level, stray currents begin to cause noise. If the differences grow large enough, they can even damage components.

Electric utilities have the biggest problems because their switching stations and power plants may have large potential differences.

A serious concern with outdoor cables in certain computer networks is that they can be hit by lightning, causing destruction to wires and other cables that are involved in the network. Certain computer companies are aware of this problem and trying to solve it by having protective devices for wire circuits to block current and voltage surges.

Any conductive cables can carry power surges or ground loops. Fiber optic cables can be made non-conductive by avoiding metal in their design. These kinds of cables are economical and standard for many indoor applications. Outdoor versions are more expensive since they require special strength members, but they can still be valuable in eliminating ground loops and protecting electronic equipment from surge damage.

**7. Eliminating Spark Hazards**

In some cases, transmitting signals electrically can be extremely dangerous. Most electric potentials create small sparks. The sparks ordinarily pose no danger, but can be really bad in a chemical plant or oil refinery where the air is contaminated with potentially explosive vapors. One tiny spark can create a big explosion. potential spark hazards seriously hinder data and communication in such facilities. Fiber optic cables do not produce sparks since they do not carry current.

**8. Ease of Installation**

Increasing transmission capacity of wire cables generally makes them thicker and more rigid. Such thick cables can be difficult to install in existing buildings where they must go through walls and cable ducts. Fiber cables are easier to install since they are smaller and more flexible. They can also run along the same routes as electric cables without picking up excessive noise.

One way to simplify installation in existing buildings is to run cables through ventilation ducts. However, fire codes require that such plenum cables be made of costly fire retardant materials that emit little smoke. The advantage of fiber types is that they are smaller and hence require less of the costly fire retardant materials. The small size, lightweight and flexibility of fiber optic cables also make them easier to be used in temporary or portable installations.

### 2.1.3 Fiber optic sensor

An optical power meter (OPM) is a device used to measure the power in an optical signal. The term usually refers to a device for testing average power in fiber optic systems. Other general purpose light power measuring devices are usually called radiometers, photometers, laser power meters, light meters or lux meters. A typical optical power meter consists of a calibrated sensor, measuring amplifier and display. The sensor primarily consists of a photodiode selected for the appropriate range of wavelengths and power levels. On the display unit, the measured optical power and set wavelength is displayed. Power meters are calibrated using a traceable calibration standard such as a NIST standard.



A traditional optical power meter responds to a broad spectrum of light, however the calibration is wavelength dependent. This is not normally an issue, since the test wavelength is usually known, however it has a couple of drawbacks. Firstly, the user must set the meter to the correct test wavelength, and secondly if there are other spurious wavelengths present, then wrong readings will result. Sometimes optical power meters are combined with a different test function such as an Optical Light Source (OLS) or Visual Fault Locator (VFL), or may be a sub-system in a much larger instrument. When combined with a light source, the instrument is usually called an Optical Loss Test Set. Optical Loss Test Sets (OLTS) are available in dedicated hand held instruments and platform-based modules to suit various network architectures and test requirements. They are used to measure optical power and power loss, and reflectance and reflected power loss. The products may also be used as optical sources or optical power meters, or to measure optical return loss or event reflectance.

Three types of equipment can be used to measure optical power loss:

1. Component equipment - Optical Power Meters (OPMs) and Stabilized Light Sources (SLSs) are packaged separately, but when used together they can provide a measurement of end-to-end optical attenuation over an optical path. Such component equipment can also be used for other measurements.

2. Integrated test set - When an SLS and OPM are packaged in one unit, it is called an integrated test set. Traditionally, an integrated test set is usually called an OLTS. GR-198, Generic Requirements for Hand-Held Stabilized Light Sources, Optical Power Meters, Reflectance Meters, and Optical Loss Test Sets, discusses OLTS equipment in depth.

3. An Optical Time Domain Reflectometer (OTDR) can be used to measure optical link loss if its markers are set at the terminus points for which the fiber loss is desired. However, a single-direction measurement may not be accurate if there are multiple fibers in a link, since the back-scatter coefficient is variable between fibers. The accuracy of such a measurement can be increased if the measurement is made as a bidirectional average of the fiber. GR-196, Generic Requirements for Optical Time Domain Reflectometer (OTDR) Type Equipment, discusses OTDR equipment in depth.


Figure 2.3: The optical power meter

## 2.2 Fibre Optic Sensor

A fiber optic sensor is a sensor that uses optical fiber either as the sensing element (intrinsic sensors), or as a means of relaying signals from a remote sensor to the electronics that process the signals (extrinsic sensors). Fibers have many uses in remote sensing. Depending on the application, fiber may be used because of its small size, or because no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using light wavelength shift for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer and wavelength shift can be calculated using an instrument implementing optical frequency domain reflectometry.

Fiber optic sensors are also immune to electromagnetic interference, and do not conduct electricity so they can be used in places where there is high voltage electricity or flammable material such as jet fuel. Fiber optic sensors can be designed to withstand high temperatures as well.Optical fibers can be used as sensors to measure strain, temperature, pressure and other quantities by modifying a fiber so that the quantity to be measured modulates the intensity, phase, polarization, wavelength or transit time of light in the fiber.

Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of intrinsic fiber optic sensors is that they can, if required, provide distributed sensing over very large distances.

Temperature can be measured by using a fiber that has evanescent loss that varies with temperature, or by analyzing the Raman scattering of the optical fiber. Electrical voltage can be sensed by nonlinear optical effects in specially-doped fiber, which alter the polarization of light as a function of voltage or electric field. Angle measurement sensors can be based on the Sagnac effect.Special fibers like long-period fiber grating (LPG) optical fibers can be used for direction recognition. Photonics Research Group of Aston University in UK has some publications on vectorial bend sensor applications.Optical fibers are used as hydrophones for seismic and sonar applications. Hydrophone systems with more than one hundred sensors per fiber cable have been developed. Hydrophone sensor systems are used by the oil industry as well as a few countries' navies. Both bottom-mounted hydrophone arrays and towed streamer systems are in use. The German company Sennheiser developed a laser microphone for use with optical fibers.

A fiber optic microphone and fiber-optic based headphone are useful in areas with strong electrical or magnetic fields, such as communication amongst the team of people working on a patient inside a magnetic resonance imaging (MRI) machine during MRI-guided surgery. Optical fiber sensors for temperature and pressure have been developed for downhole measurement in oil wells. The fiber optic sensor is well suited for this environment as it functions at temperatures too high for semiconductor sensors (distributed temperature sensing). Optical fibers can be made into interferometric sensors such as fiber optic gyroscopes, which are used in the Boeing 767 and in some car models (for navigation purposes). They are also used to make hydrogen sensors. Fiber-optic sensors have been developed to measure co-located temperature and strain simultaneously with very high accuracy using fiber Bragg gratings. This is particularly useful when acquiring information from small or complex structures. Fiber Bragg grating sensors are also particularly well suited for remote monitoring, and they can be interrogated 250 km away from the monitoring station using an optical fiber cable. Brillouin scattering effects can also be used to detect strain and temperature over large distances (20–120 kilometers).

Extrinsic fiber optic sensors use an optical fiber cable, normally a multimode one, to transmit modulated light from either a non-fiber optical sensor, or an electronic sensor connected to an optical transmitter. A major benefit of extrinsic sensors is their ability to reach places which are otherwise inaccessible. An example is the measurement of temperature inside aircraft jet engines by using a fiber to transmit radiation into a radiation pyrometer located outside the engine. Extrinsic sensors can also be used in the same way to measure the internal temperature of electrical transformers, where the extreme electromagnetic fields present make other measurement techniques impossible. Extrinsic fiber optic sensors provide excellent protection of measurement signals against noise corruption. Unfortunately, many conventional sensors produce electrical output which must be converted into an optical signal for use with fiber. For example, in the case of a platinum resistance thermometer, the temperature changes are translated into resistance changes. The PRT must therefore have an electrical power supply. The modulated voltage level at the output of the PRT can then be injected into the optical fiber via the usual type of transmitter. This complicates the measurement process and means that low-voltage power cables must be routed to the transducer. Extrinsic sensors are used to measure vibration, rotation, displacement, velocity, acceleration, torque, and temperature.

### 2.2.1 Extrinsic Sensors



Optical fibers can be used as sensors to measure strain, temperature, pressure and other quantities by modifying a fiber so that the quantity to be measured modulates the intensity, phase, polarization, wavelength or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of intrinsic fiber optic sensors is that they can, if required, provide distributed sensing over very large distances.

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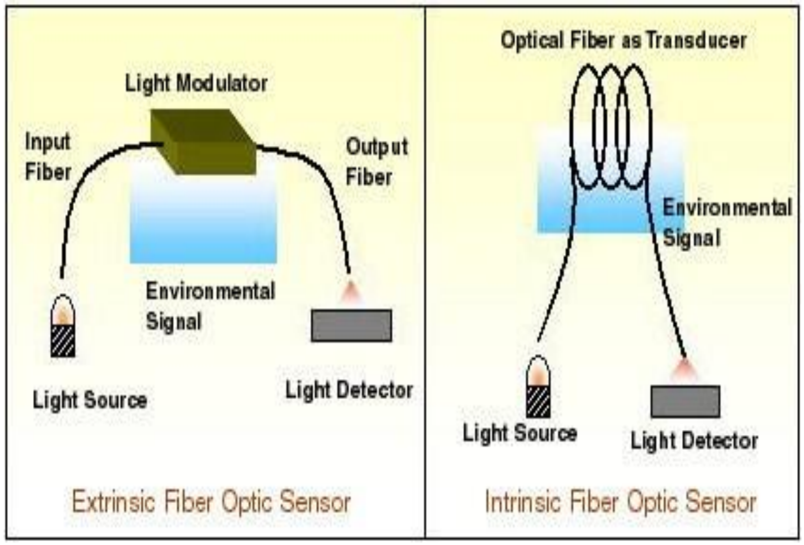



**Figure 2.4**: Extrinsic and intrinsic types of fibre optic sensors.

### 2.2.3 Optical methods to study and control the brain

V Doronina-Amitonova, I V Fedotov1, A B Fedotov, K V Anokhin and A M Zheltikov (2015) reported that the Methods of optical material science offer one of a kind open doors for the examination of cerebrum and higher anxious action. The mix of bleeding edge laser advances and propelled neurobiology opens another cross-disciplinary region of common sciences – neurophotonics – concentrating on the improvement of an unlimited armory of instruments for useful cerebrum diagnostics, incitement of individual neurons and neural systems, and the sub-atomic designing of mind cells went for the analysis and treatment of neurodegenerative and psychic illnesses. Optical filaments stand up to the most difficult issues in cerebrum research, including the examination of sub-atomic cell systems of the arrangement of memory and conduct. New era optical filaments give new answers for the improvement of in a general sense new, exceptional device for neurophotonics and laser neuroengineering – fiber-optic neuroendoscopes and neurointerfaces. These instruments widen research skylines when exploring the most complex cerebrum capacities, empowering a long haul multiplex discovery of fluorescent protein markers, and also photostimulation of neuronal action in profound mind zones in living, openly moving creatures with an uncommon spatial determination and negligible obtrusiveness. This developing innovation opens new skylines for comprehension learning and long haul memory through tests with living, uninhibitedly moving warm blooded creatures. Here, we show a brief survey of this quickly developing field of exploration.

### 2.2.4 Fiber optic hydrogen gas sensor utilizing surface plasmon resonance and native defects of zinc oxide by palladium

In view of Rana Tabassum and Banshi D Gupta (2015) reported that a test study on a surface plasmon reverberation (SPR) based fiber optic hydrogen gas sensor utilizing a palladium doped zinc oxide nanocomposite ($ZnO(1-x) Pd x$ , $0 \leq x \leq 0.85$) layer over the silver covered unclad center of the fiber. Palladium doped zinc oxide nanocomposites ($ZnO(1-x) Pd x$ ) are set up by a concoction course for various piece proportions and their auxiliary, morphological and hydrogen detecting properties are examined tentatively. The detecting standard includes the ingestion of hydrogen gas by $ZnO(1-x) Pd x$ , adjusting its dielectric capacity. The adjustment in the dielectric steady is broke down as far as the red movement of the reverberation wavelength in the noticeable locale of the electromagnetic range. To check the detecting ability of detecting tests manufactured with changing piece proportion (x) of nanocomposite, the SPR bends are recorded regularly for 0% H2 and 4% H2 in N2 environment for each created test. On changing the convergence of hydrogen gas from 0% to 4%, the red movement in the SPR range affirms the adjustment in dielectric steady of $ZnO(1-x) Pd x$ on presentation to hydrogen gas. It is noticed that the movement in the SPR range increments monotonically up to a specific portion of Pd in zinc oxide, past which it begins diminishing. SEM pictures and the photoluminescence

(PL) spectra uncover that Pd dopant particles substitutionally consolidated into the ZnO cross section significantly influence its imperfection levels; this is in charge of the ideal arrangement of ZnO(1−x)Pd x to sense the hydrogen gas. The sensor is exceedingly specific to hydrogen gas and has high affectability. Since optical fiber detecting innovation is utilized alongside the SPR strategy, the present sensor is equipped for remote detecting and web observing of hydrogen gas.

### 2.2.5 Enhancing thermal reliability of fiber-optic sensors for bio-inspired applications at ultra-high temperatures

Donghoon Kang, Heon-Young Kim and Dae-Hyun Kim (2014) recommended that The quick development of bio-(motivated) sensors has prompted a change in current medicinal services and human–robot frameworks as of late. Larger amounts of unwavering quality and better adaptability, key components of these sensors, are especially required in numerous application fields (e.g. applications at ultra-high temperatures). Fiber-optic sensors, and fiber Bragg grinding (FBG) sensors specifically, are in effect generally concentrated on as appropriate sensors for enhanced auxiliary wellbeing observing (SHM) because of their numerous benefits. To upgrade the warm dependability of FBG sensors, warm affectability, for the most part communicated as αf + ξf and considered a consistent, ought to be examined all the more decisively. For this reason, the administering condition of FBG sensors is adjusted utilizing differential subordinates between the wavelength shift and the temperature change in this study. Through a warm test going from RT to 900 °C, the warm affectability of FBG sensors is effectively inspected and this assurances warm unwavering quality of FBG sensors at ultra-high temperatures. In point of interest, αf + ξf has a non-direct reliance on temperature and fluctuates from 6.0 × 10−6 °C−1 (20 °C) to 10.6 × 10−6 °C−1 (650 °C). Likewise, FBGs ought to be precisely utilized for applications at ultra-high temperatures because of sign vanishing almost 900 °C.

### 2.2.6 Optimized Tapered Optical Fiber for Ethanol Concentration Sensing

Hang-Zhou Yang (2014) state that an enhanced investigation of biconical decreased multi-mode plastic optical fiber sensor for focus detecting of ethanol (C2H5OH) is introduced. The affectability is improved through V-number coordinating and also by streamlining the decrease span and decrease length. The beam following technique is utilized to break down the transient wave infiltration profundity (EWPD). The hypothetical investigation and exploratory results are utilized to enhance the decrease proportion and decrease length for the accomplishment of high EWPD and high affectability. The examination demonstrates that the affectability of decreased fiber sensor can be enhanced by diminishing the decrease proportion with synchronous increment in the decrease length. The most elevated affectability of 1.527 mV/% is accomplished from the decreased fiber with a decrease proportion of 0.27 and decrease length of 8 cm. The proposed parametric advanced decreased fiber sensor can recognize the adjustment in convergence of C2H5OH as little as 6.55 × 10-3.



### 2.2.7 Refractometric optical fiber sensor for measurement of ethanol concentration in ethanol-gasoline blend

Gustavo Rafael Collere Possetti (2009) state that an optical fiber gadget in view of long stretch grinding is connected as refractive file transducer to gauge the ethanol fixation in ethanol-gas mixes. The gadget metrological qualities - reaction bend, affectability, determination, congruity, repeatability, consolidated instability and extended vulnerability - were resolved and contrasted and attributes connected with an Abbe refractometer. For ethanol focus going from 20% to 40%, the LPG joined instability was 0.70% and the extended vulnerability was 1.70 %.

### 2.2.8 Application of an Optical Fiber Sensor on the Determination of Sucrose and Ethanol Concentrations in Process Streams and Effluents of Sugarcane Bioethanol Industry

Eric Fujiwara (2012) report that the measurement of process streams and effluents from the sugar-ethanol industry using an optical fiber sensor based on the Fresnel reflection principle is reported. Firstly, binary sucrose-water and ethanol-water solutions with predetermined concentrations were measured for calibration purposes. Secondly, the coproducts from various processing stages were analyzed in order to identify the sucrose or ethanol content. The measured data were processed by an artificial neural network model, which correlated the reflected intensity values to the sample concentration. The absolute error was calculated by a comparison between the nominal concentration values obtained by the plant laboratory analysis and the sensor response, yielding errors ≤ 3& wt% and ≤ 5.1 vol% for the sucrose and ethanol contents, respectively. The fiber sensor has the potential to provide reliable results even for samples with more complex compositions than pure sucrose or ethanol solutions, with perspectives of application on the several stages of the plant facility.



## 2.3 Ethanol

Ethanol also commonly called ethyl alcohol, drinking alcohol, or simply alcohol is the principal type of alcohol found in alcoholic beverages, produced by the fermentation of sugars by yeasts. It is a neurotoxic psychoactive drug and one of the oldest recreational drugs used by humans. It can cause alcohol intoxication when consumed in sufficient quantity.

Ethanol is a volatile, flammable, colorless liquid with a slight chemical odor. It is used as an antiseptic, a solvent, a fuel, and, due to its low freezing point, the active fluid in post-mercury thermometers. The molecule is a simple one, being an ethyl group linked to a hydroxyl group. Its structural formula, CH3CH2OH, is often abbreviated as C2H5OH, C2H6O or EtOH.

# CHAPTER 3

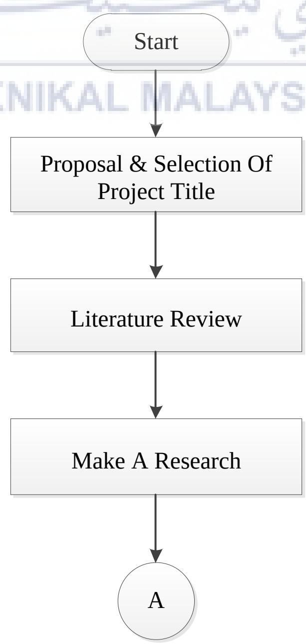
# METHODOLOGY

## 3.0 Introduction

This chapter discuss the methodology used to conduct this project. The topic discusses would be the selection of the title and the flowchart of this project.

## 3.1 Flow Chart





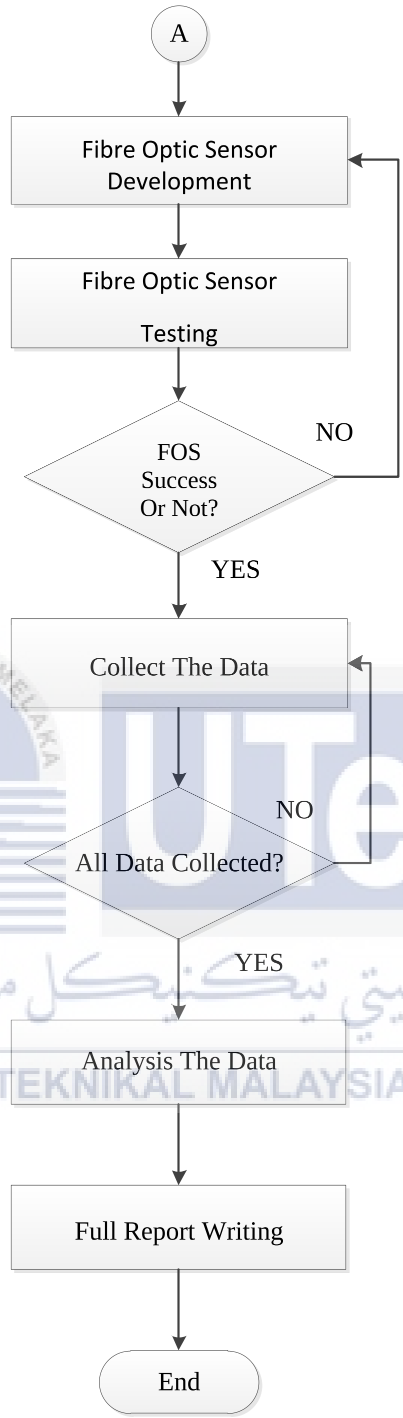



Figure 3: Project Flowchart

### 3.1.1 Proposal and Selection of Title

The title of this project is selected based on the current topic in the sensorand is narrow down to the fiber optic sensor. The topic is selected based on the criteria, which are, simple yet beneficial; no other research has been made regarding the topic; capable to be conducted within the allowcated period of time; and lastly inexpensive. Then discussions are made with the supervisor as to seek the guidance and advices. The discussions are to be made at least once a week. Such discusson is also be made as to consult about the availability of the instrument such as the light source. This discussions is made weekly to report weekly progress of the project.

### 3.1.2 Literature Review

After discussion with supervisor and team members, the literature review of the related issues would be conducted. The review require a few weeks to completed.

The literature review is made by using the online journal source such as EZ Proxy to seek the related issues of the project. The literature review is conducted as to review the current topics related to the Fiber Optic Sensor (FOS)



### 3.1.3 Make a Research

The process then was proceed to methodology research. A further research was made to ensure the best method to be used in FOS. In this section, a suitable technique would be implemented when developing the FOS to avoid any mistake from happening.

### 3.1.4 Fiber Optic Sensor Development

In this section the project is further by developing the Fiber Optic Sensor (FOS). This project development is conducted at the Faculty of Engineering Technology Laboratory. Before starting the process of FOS, the raw material inspection is done by seeking the best raw material that will be used. The selection is made based on the selection of title. The inspection is made to ensure the material and parameter that will used in this project was correct. The development used most of the laboratory equipment such as splicing device.

1. Began process with stripping to remove the cladding at the middle of fiber optic cable

Figure 3.1: Stripping process



2. Use Fiber Cleaver to cut the lever of core optical fiber

Figure 3.2: Cutting process

3. Use tissue with alcohol to remove the dust

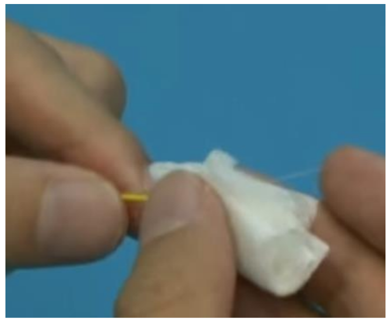


Figure 3.3: Dust removal process

4. Use ARC splicer to combine the separate fiber optic core, this splicer use to combine single mode optical fiber with pig tail single mode optical fiber.


Figure 3.4: Splicing process



5. Test fiber optic sensor with Amplifier Spontaneous Emission (ASE) and Optical Spectrum Analyzer (OSA) to identify the power loss.

Figure 3.4: Power loss test process

### 3.1.5 Experiment process.

1. Perfume was put in the jug for starter

Figure 3.6: Perfume

2. The perfume used in this process


Figure 3.7: Four type of perfume used in this experiment

3. Fiber optic sensors was insert into water

Figure 3.8: The position of fiber optic sensor inside the perfume during experiment

4. Start to collect data

Figure 3.9: Collect the data every 5 minutes for 1 hour.

### 3.1.5 Fibre Optic Sensor Testing

The FOS was testing by using the optical power meter. An optical power meter (OPM) is a device used to measure the power in an optical signal. A FOS testing is made as it will help to determine the functionality of the fibre optic sensor. In this section a calibration of the light sensor is conducted as to allows the error would be minimised.

If the testing is failed, the step should be back to the developement of the FOS. On the other hand, if the testing is successful, thus the procedure should collection of data

### 3.1.6 Hardware and Eqiupment

The hardware and equipment that are used to completing this project are list below:

**a) OSA (Optical Spectrum Analyzer)**

An Optical Spectrum Analyzer (or OSA) is a precision instrument designed to measure and display the distribution of power of an optical source over a specified wavelength span. An OSA trace displays power in the vertical scale and the wavelength in the horizontal scale

Figure 3.10: Optical Spectrum Analyzer

**b) ASE (Amplified Spontaneous Emission)**

To measure the channel wavelength in a laser medium with the large gain, the luminescence from spontaneous emission can be amplifier to high power level.


Figure 3.11: Amplifier Spontaneous Emission

**c) Single Mode Fiber Optic**

The medium channel was made from glass to reflex with light. This single mode fiber optic will be developing as a fiber optic sensor to sensory the concentration of material.Single mode fiber is optical fiber that is designed for the transmission of a single ray or mode of light as a carrier and is used for long-distance signal transmission.

Figure 3.12: Single Mode Fiber Optic

**d) Single Pigtail Fiber Optic**

A fiber pigtail is a single, short, usually tight-buffered, optical fiber that has an optical connector pre-installed on one end and a length of exposed fiber at the other end.

The end of the pigtail is stripped and fusion spliced to a single fiber of a multi-fiber trunk. Splicing of pigtails to each fiber in the trunk "breaks out" the multi-fiber cable into its component fibers for connection to the end equipment.

Pigtails can have female or male connectors. Female connectors could be mounted in a patch panel, often in pairs although single-fiber solutions exist, to allow them to be connected to endpoints or other fiber runs with patch fibers. Alternatively they can have male connectors and plug directly into an optical transceiver

Figure 3.13: Pigtail cable



**e) Perfume**

Perfume is a mixture of fragrant essential oils or aroma compounds, fixatives and solvents. It used to give the human body "a pleasant scent".


Figure 3.14: Four Type of Perfume

**f) Fusion Splicer**

Fusion splicing is the act of joining two optical fibers end-to-end using heat. The goal is to fuse the two fibers together in such a way that light passing through the fibers is not scattered or reflected back by the splice, and so that the splice and the region surrounding it are almost as strong as the virgin fiber itself. The source of heat is usually an electric arc, but can also be a laser, or a gas flame, or a tungsten filament through which current is passed.

Figure 3.15: Fusion Splicer



### 3.1.8 Collect The Data

After the fiber optic sensor testing is done, then the collection of data may be begin immediately. The data obtain is based on the concentration of ethanol in perfume by using the optical power meter to measure the power in an optical signal. Using 4 type of light source 850nm, 1300nm, 1310nm and 1550nm, the data collect for every 5 minute until 60 minute. If all data have been collected, then proceed to analysis the data. If not collect, the go back to collect the data process.

### 3.1.9 Analysis The Data

The data collected will be analyzed. The statistical graph will be made after the data be analyzed. Based on the data graph, a hypothesis can be made to find out the four type of perfume have alcohol content or not.

## 3.2 Report writing

This is the last part of this project. All document which include collection of data, discussion, conclusion and future recommendation are all writtenin single report. The reference also include in this section as a proof of this project.

# CHAPTER 4
# RESULT & DISCUSSION

## 4.0 Introduction

In this chapter discuss about different type of perfume has been used in this project. The fiber optic has been used as a sensor to detect the alcohol level in the perfume. Four light source 850nm, 1300nm, 1310nm and 1550nm have been tested on the perfume. The data obtain will be discuss in this chapter.

## 4.1 Project Setup

The project setup in this project is as referred in figure below. The figure shows the block diagram of the fiber optic sensor for different type of perfume. Four light source 850nm, 1300nm, 1310nm and 1550nm have been tested on the perfume. By using the proper equipment, single mode fiber optic sensor connected to the pigtail by using splicing method. Then different type of perfume was tested at the center of fiber optic sensor between light source (ASE) and Optical Spectrum Analyzer (OSA). After that, the results are collected, plotted into graph and the observation was discussed

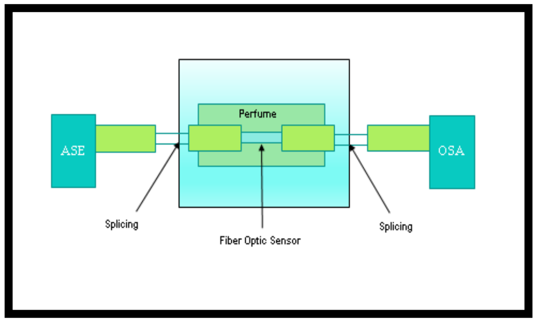



**Figure 4.1:** Schematic Diagram of the Fibre Optic Sensor for alcohol detection in perfume

The figure above is the fibre optic sensor. The perfume will be put in at the middle of the fibre. The light will transmit from Amplified Spontaneous Emission (ASE) through the fibre optic cable and will detect the concentration of perfume in the sensor. The result will be measured by the Optical Spectrum Analyser (OSA).

## 4.2 Result and Discussion

### 4.2.1 Light Source 850



Table 4.0 below shows the reading of the perfume for light source 850nm. The reading was taken every 5 minute for 60 minute. There are 4 type of perfume was used in this such as brand A, B, C and D. The data was taken in dB. All the data for all type of perfume was analyzed by using Microsoft Excel software.

**Table 4.1:** Light Source 850

| Light Source 850 | | | | |
|---|---|---|---|---|
| **TIME** | A | B | C | D |
| **0** | 40.47 | 42.21 | 40.43 | 43.09 |
| **5** | 40.47 | 42.21 | 40.43 | 43.09 |
| **10** | 40.47 | 42.21 | 40.42 | 43.09 |
| **15** | 40.46 | 42.21 | 40.42 | 43.09 |
| **20** | 40.46 | 42.21 | 40.41 | 43.09 |

| | | | | |
|---|---|---|---|---|
| **25** | 40.46 | 42.21 | 40.41 | 43.09 |
| **30** | 40.46 | 42.21 | 40.41 | 43.09 |
| **35** | 40.46 | 42.21 | 40.41 | 43.09 |
| **40** | 40.46 | 42.21 | 40.41 | 43.09 |
| **45** | 40.46 | 42.21 | 40.41 | 43.09 |
| **50** | 40.46 | 42.21 | 40.41 | 43.09 |
| **55** | 40.46 | 42.21 | 40.41 | 43.09 |
| **60** | 40.46 | 42.21 | 40.41 | 43.09 |

The figure 4.1 below shows the graph for light source 850 for all type of perfume for 60 minute. The data was analyzed by using regression method. Based on the graph below, it can be seen that brand D perfume has the highest loss compare to other type of perfume while brand A and brand C are the lowest and has a similar loss.

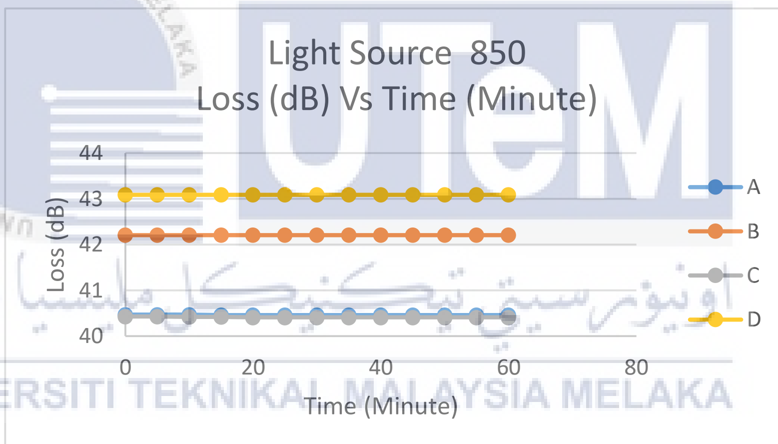





**Figure 4.2:** Graph for all perfume type at light source 850nm

The figure 4.2 below show the graph for brand A type perfume for light source 850nm. The analysis was done by taking the data from slope on the graph. Based on the graph below, the data was analyzed from 0-10 minutes and 15-60 minute. From 0-10 minute the data was stable and decreased at 10-15. Then from 15-60 it remain constant until end.

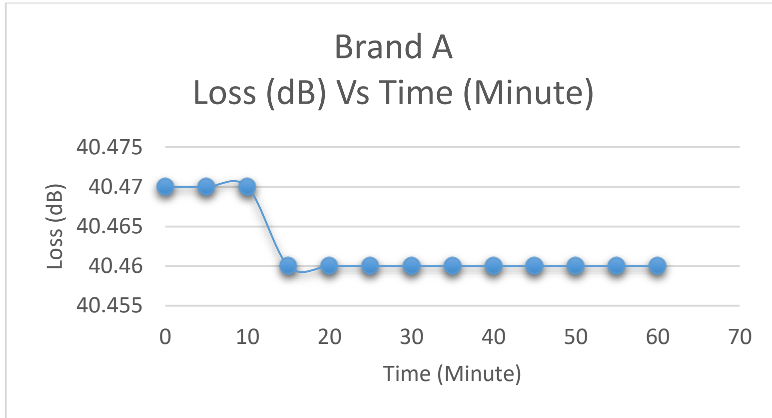



**Figure 4.3:** Graph of brand A type perfume

The figure 4.3 below shows the graph of brand B perfume for light source 850nm. The analysis was done by using regression method. Based on the graph below, the data was analyzed from 0-60 minutes. From 0-60 minutes the data was stable.




**Figure 4.4:** Graph of brand B type perfume

The figure 4.4 below shows the graph of brand C perfume for light source 850nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-5 minute, 10-15 minute and 20-60 minute. For the 0-5 minute the graph was stable until it decreased from 5-10 minutes. Then again it stable from 10-15 minute and decrease from15-20 minutes. After that it remain stable from 20-60 minutes.

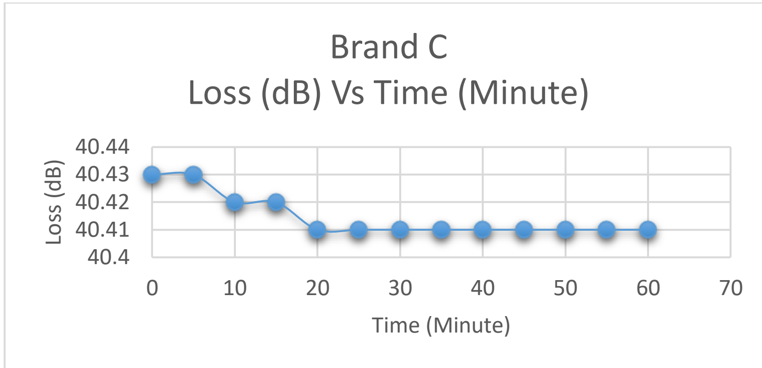



**Figure 4.5:** Graph of brand C type perfume

The figure 4.5 below shows the graph of brand D perfume for light source 850nm. The analysis was done by using regression method. Based on the graph below, the graph was stable from 0-60 minutes.



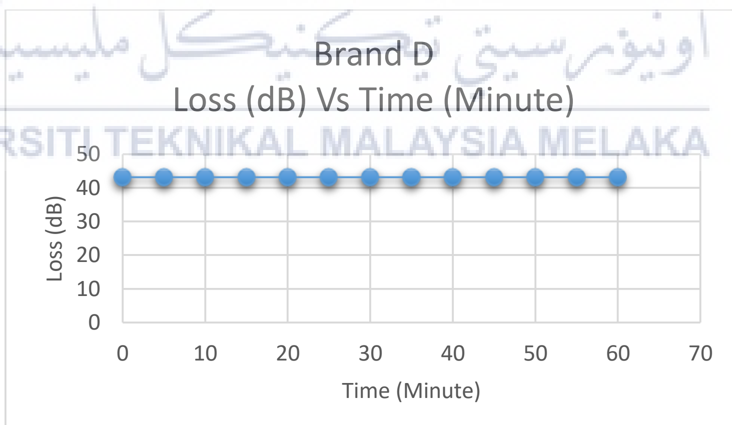



**Figure 4.6:** Graph of brand D type perfume

### 4.2.2 Light Source 1300

Table 4.1 below shows the data of all perfume for light source 1300nm for 60 minutes. The analysis was done by using regression method. The reading was taken every 5 minute for 60 minute. There are 4 type of perfume was used in this such as brand A, B, C and D. The data was taken in dB. All the data for all type of perfume was analyzed by using Microsoft Excel software.

**Table 4.2:** Light source 1300

| Light Source 1300 | | | | |
|---|---|---|---|---|
| **TIME** | A | B | C | D |
| **0** | 41.97 | 41.97 | 40.6 | 43.97 |
| **5** | 41.97 | 41.97 | 40.6 | 43.97 |
| **10** | 41.96 | 41.96 | 40.6 | 43.97 |
| **15** | 41.96 | 41.96 | 40.59 | 43.97 |
| **20** | 41.96 | 41.96 | 40.59 | 43.97 |
| **25** | 41.96 | 41.96 | 40.59 | 43.97 |
| **30** | 41.97 | 41.96 | 40.59 | 43.98 |
| **35** | 41.96 | 41.96 | 40.59 | 43.97 |
| **40** | 41.96 | 41.96 | 40.59 | 43.97 |
| **45** | 41.96 | 41.96 | 40.59 | 43.97 |
| **50** | 41.96 | 41.96 | 40.59 | 43.97 |
| **55** | 41.96 | 41.96 | 40.58 | 43.97 |
| **60** | 41.95 | 41.96 | 40.58 | 43.97 |



The figure 4.6 below shows the graph for light source 1300 for all type of perfume. The data was analyzed by using regression method. Based on the graph below, it can be seen that the brand D perfume has the highest loss compare to other type of perfume while brand C has the lowest loss. Brand A and brand B has similar loss value.

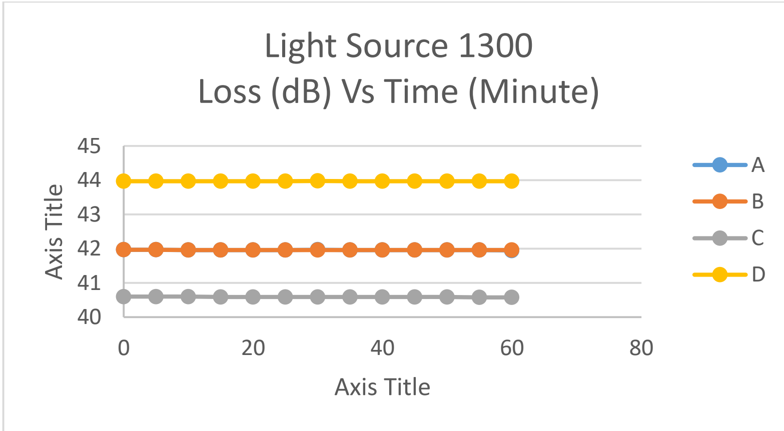



**Figure 4.7:** Graph for all perfume type at light source 1300nm

The figure 4.7 below shows the graph of brand A perfume for light source 1300nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-5 minute, 10-20 minute, 25-35 minute and 40-60 minute. At 0-5 minute, the graph was stable until it decreased from 5-10 minute. After that, at for 10 minute it stable from10-20 minute. From minute 25-35, it increased at 25-30 minute and decreased at 30-35 minute. Then it stable until 55 minute and decreased at 60 minute




**Figure 4.8:** Graph of brand A perfume

The figure 4.8 below shows the graph of brand B perfume for light source 1300nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-5 minute and 10-60 minute. At 0-5 minute, the graph was stable and then decreased from 5-10 minutes. After that it stable from 10-60 minutes.


**Figure 4.9:** Graph of brand B perfume

The figure 4.9 below shows the graph of brand C perfume for light source 1300nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-10 minutes, 15-50 minutes and 55-60 minutes. From 0-10 minutes, the graph was stable until it decreased from 10-15 minutes. After that it stable from 15-50 minutes and decreased from 50-55 minutes. Then is stable from 55-60 minutes.

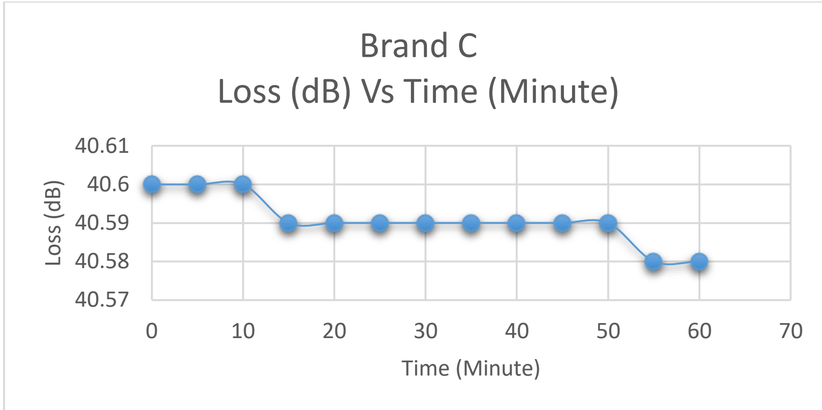



**Figure 4.10:** Graph of brand C perfume

The figure 4.10 below shows the graph of brand D perfume for light source 1300nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-25 minutes, 30-35 minutes, and 40-60 minutes. From 0-25 minutes, the graph was stable until it increased from 25-30 minutes. Then it decreased from 30-35 minutes. After that it stable from 40-60 minutes.



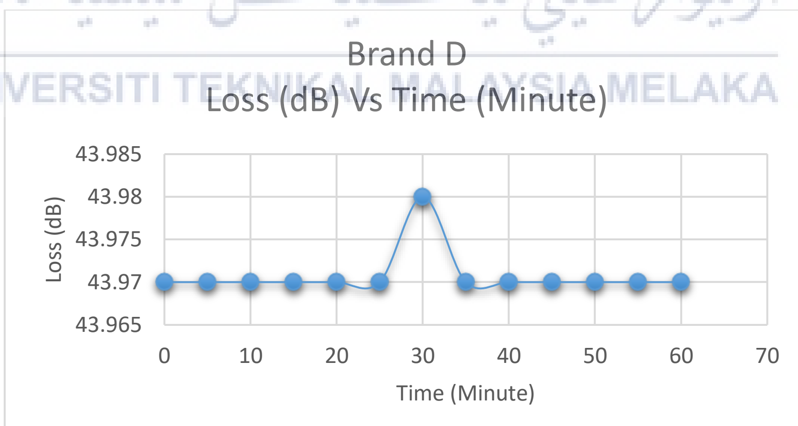



**Figure 4.11:** Graph of brand D perfume

### 4.2.3 Light Source 1310

Table 4.2 below shows the data of all perfume for light source 1310nm. The analysis was done by using regression method. The reading was taken every 5 minute for 60 minute. There are 4 type of perfume was used in this such as brand A, B, C and D. The data was taken in dB. All the data for all type of perfume was analyzed by using Microsoft Excel software.

**Table 4.3:** Light Source 1310

| **Light Source 1310** | | | | |
|---|---|---|---|---|
| **TIME** | **A** | **B** | **C** | **D** |
| **0** | 8.57 | 8.73 | 7.06 | 7.54 |
| **5** | 8.55 | 8.75 | 7.06 | 7.53 |
| **10** | 8.54 | 8.78 | 7.06 | 7.53 |
| **15** | 8.53 | 8.78 | 7.06 | 7.53 |
| **20** | 8.52 | 8.8 | 7.06 | 7.53 |
| **25** | 8.52 | 8.82 | 7.06 | 7.52 |
| **30** | 8.5 | 8.84 | 7.07 | 7.52 |
| **35** | 8.49 | 8.85 | 7.07 | 7.52 |
| **40** | 8.49 | 8.86 | 7.07 | 7.52 |
| **45** | 8.49 | 8.87 | 7.07 | 7.52 |
| **50** | 8.48 | 8.89 | 7.07 | 7.52 |
| **55** | 8.48 | 8.9 | 7.07 | 7.51 |
| **60** | 8.48 | 8.93 | 7.07 | 7.51 |

The figure 4.11 below shows the graph for light source 1310 for all type of perfume. The data was analyzed by using regression method. Based on the graph below, it can be seen that brand B perfume has the highest loss followed by brand A perfume and brand D perfume. Brand C perfume has the lowest loss.

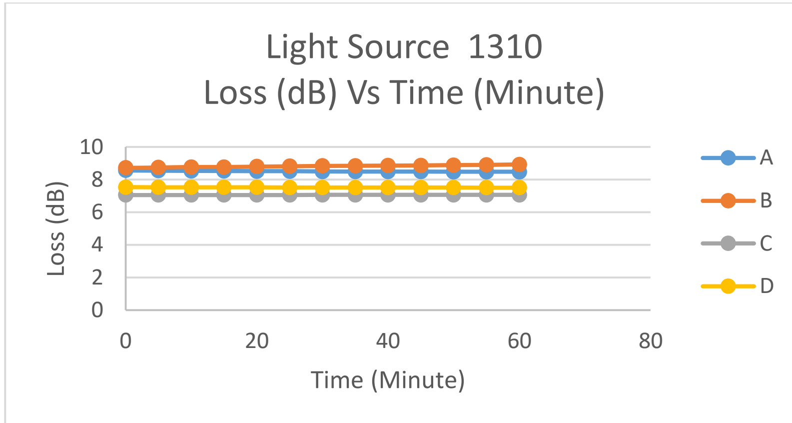



**Figure 4.12:** Graph for all perfume type at light source 1310nm

The figure 4.12 below shows the graph of brand A perfume for light source 1310nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-20 minutes, 25-45 minutes and 50-60 minutes. From 0-20 minutes, the graph was decreased until it stables from 20-25 minutes. Then it decreased from 25-40 minutes. After that it stables for 5 minutes from 40-45 minutes and decrease from 45-50 minutes. Lastly it stable for 10 minutes from 50-60 minutes.



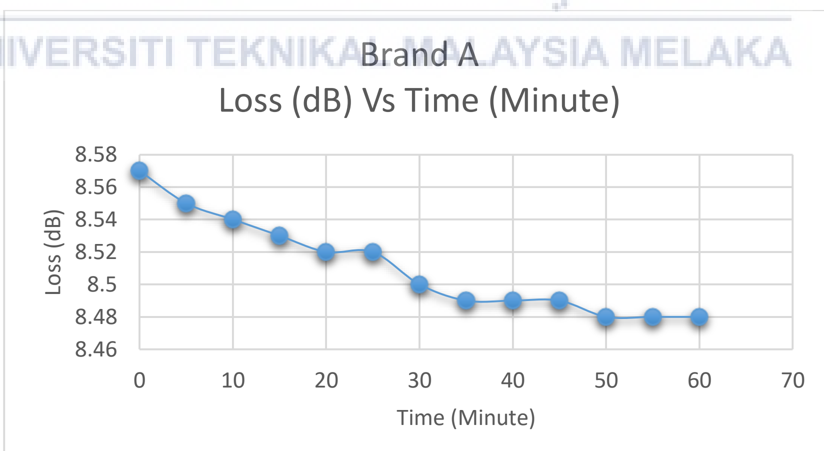



**Figure 4.13:** Graph of brand A perfume

The figure 4.13 below shows the graph of brand B perfume for light source 1310nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-15 minutes and 15-60 minutes. From 0-10 minutes, the graph was until it stable from 010-15 minutes. Then it increase from 15-60 minutes. Mostly of the graph was decreased.


**Figure 4.14:** Graph of brand B perfume



The figure 4.14 below shows the graph of brand C perfume for light source 1310nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-25 minutes and 30-60 minutes. From 0-25 minutes the graph was stable until it increased at 25-30 minutes. Then, it stable from 30-60 minutes.

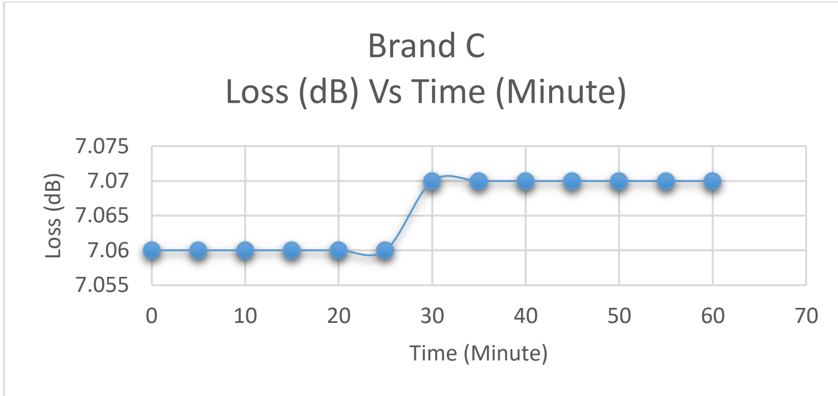



**Figure 4.15:** Graph of brand C perfume

The figure 4.15 below shows the graph of brand D perfume for light source 1310nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-20 minutes, 25-50 minutes and 55-60 minutes. From 0-20 minutes, the graph was decreased at 0-5 minutes and stable from 5-20 minutes. Then from 20-50 minutes, the graph was decreased at 20-25 minutes and stable at 25-50 minutes. After that from 50-60 minutes it decreased at 50-55 minutes and stable at 55-60 minutes.



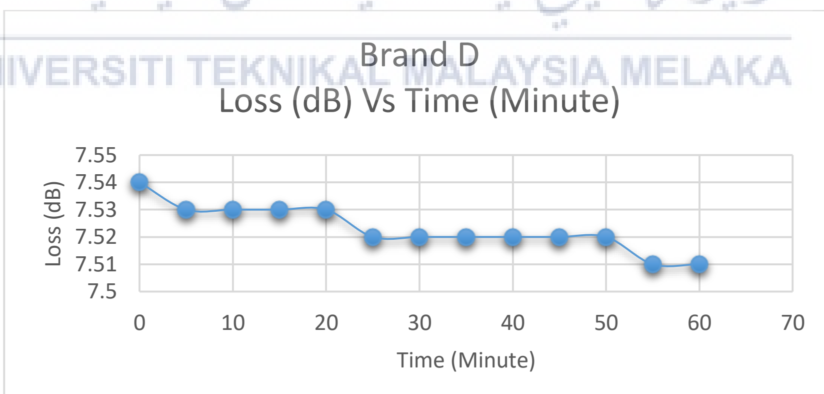



**Figure 4.16:** Graph of brand D perfume

### 4.2.4 Light Source 1550

Table 4.3 below shows the data of all perfume for light source 1550nm. The analysis was done by using regression method. The reading was taken every 5 minute for 60 minute. There are 4 type of perfume was used in this such as brand A, B, C and D. The data was taken in dB. All the data for all type of perfume was analyzed by using Microsoft Excel software.

**Table 4.4:** Light Source 1550

| Light Source 1550 | | | | |
|---|---|---|---|---|
| **TIME** | A | B | C | D |
| **0** | 7.32 | 6.14 | 7.44 | 8.72 |
| **5** | 7.32 | 6.14 | 7.44 | 8.72 |
| **10** | 7.32 | 6.14 | 7.44 | 8.73 |
| **15** | 7.32 | 6.14 | 7.44 | 8.73 |
| **20** | 7.32 | 6.14 | 7.44 | 8.72 |
| **25** | 7.32 | 6.14 | 7.44 | 8.72 |
| **30** | 7.33 | 6.15 | 7.44 | 8.71 |
| **35** | 7.33 | 6.14 | 7.44 | 8.71 |
| **40** | 7.33 | 6.15 | 7.44 | 8.71 |
| **45** | 7.33 | 6.16 | 7.44 | 8.71 |
| **50** | 7.33 | 6.17 | 7.44 | 8.71 |
| **55** | 7.34 | 6.17 | 7.44 | 8.71 |
| **60** | 7.34 | 6.17 | 7.44 | 8.7 |



The figure 4.16 below shows the graph for light source 1550 for all type of perfume. The data was analyzed by using regression method. Based on the graph below, it can be seen that the brand D perfume has the highest loss followed by brand C and brand A perfume that has similar result. Brand B perfume has the lowest loss.

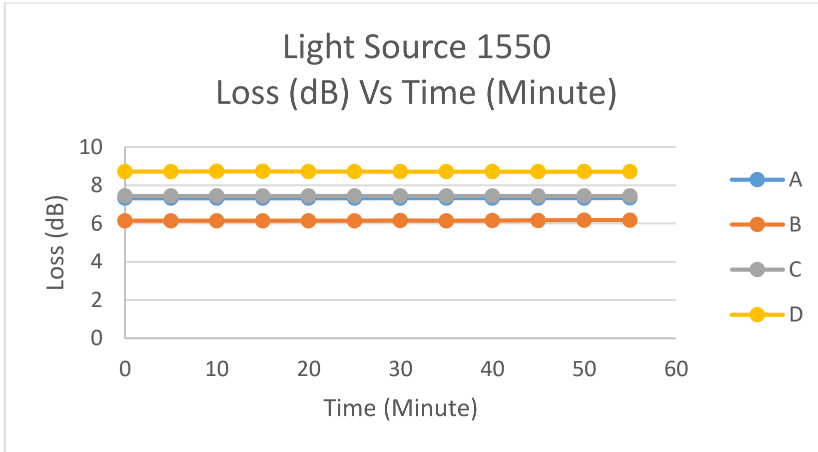



**Figure 4.17:** Graph for all perfume type at light source 1550nm

The figure 4.17 below shows the graph of brand A perfume for light source 1550nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-30 minutes, 35-60 minutes. From 0-30 minutes, the graph was stable at 0- minutes until it increased at 25-30 minutes. From 35-60 minutes, the graph was stable at 35-50 minutes and increase at 50-55 minutes.




**Figure 4.18:** Graph of brand A perfume

The figure 4.18 below shows the graph of brand B perfume for light source 1550nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-20 minutes, 25-35 minutes and 40-60 minutes. From 0-20 minutes, the graph was stable. From 25-35 minutes the graph was increased at 25-30 minutes and decreased at 30-35 minutes. From 40-60 minutes the graph was increased at 40-50 minutes and stable from 50-60 minutes.


**Figure 4.19:** Graph of brand B perfume

The figure 4.19 below shows the graph of brand C perfume for light source 1550nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the data was analyzed from 0-60 minutes was stable.



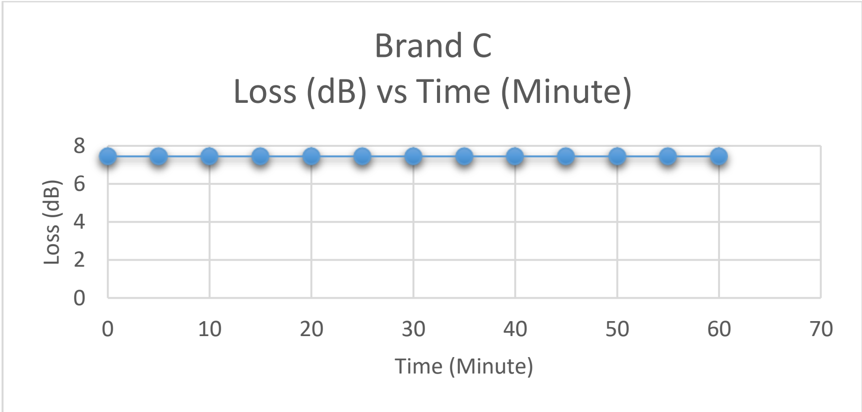



**Figure 4.20**: Graph of brand C perfume

The figure 4.20 below shows the graph of brand D perfume for light source 1550nm. To analyzed the data, regression method was used. The analysis was done by taking the reading based on the slope in the graph. Based on the graph below, the slope was analyzed from 0-25 minutes and 30-60 minutes. From 0-25 minutes, the graph was stable for 5 minutes at 0-5 minutes until it increased at 5-10 minutes. Then it stable at 10-15 minutes and decreased 15-25 minutes. From 30-60 minutes, the graph was stable at 30-55 minutes and decreased at 55-60 minutes.

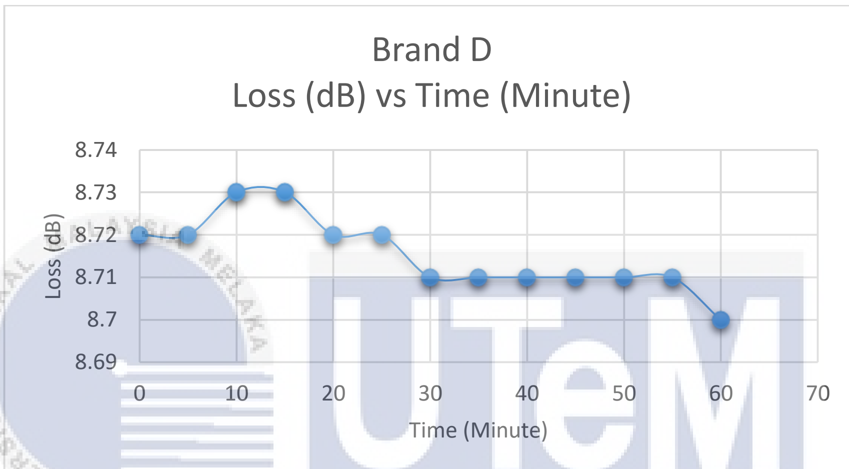



**Figure 4.21**: Graph of brand D perfume



## 4.3 Discusssion

In this section will discuss about data analyze based on data collected from the experiment. The analyze was about fiber optic sensor for detecting alcohol level in perfume (ethanol). The analyze method used in excel tool knew as regression data analyze. This regression is one of the mathematical order uses to read the summary output based on data collected. Before start the analyze, there will four major factor will be look as reference to analyze the data. There is about linear range, correlation R, correlation of determination (COD), and sensitivity. The function for four categories is describe below as references:

- Linear range – The duration to complete the data.
- Correlation R – The accuracy of data taken.
- Coefficient of determination (COD) – The percentage of molecule contain in perfume such as response of ethanol that detected by fiber optic sensor.
- Sensitivity – Tell about how sensitive of FOS against of material use in lab experiment.

This data analyzes based on data collected during lab experiment. By using optical fiber light source 850nm, 1300nm, 1310nm, and 1550nm which is laser light source through the fiber cable from transmitter to receiver. All table below show analyze from all four type of perfume

### 4.3.1 Data Analyze Base On Light source 850nm on four type of perfume.

Linear range is the time use to test the FOS performance against the four type of perfume. The duration 60 minutes was used to find the result and the table below is the outcome of the test.



**Table 4.5:** Data analyze of light source 850nm test on four type of perfume

| Light Source 850nm | | | | |
|---|---|---|---|---|
| **Brand** | A | B | C | D |
| **Linear Range (Minute)** | 0-60 | 0-60 | 0-60 | 0-60 |
| **Correlation R** | 0.648 | 1 | 0.735 | 1 |
| **COD (%)** | 64.77% | 100% | 78.55% | 100% |
| **Sensivity** | 0.0001 | 0 | 0.0003 | 0 |

Correlation R is referring to accuracy data collected from lab experiment. To identify either the data is accurate, the correlation must near to 1.0 as a reference. The nearer the data to the 1.0, the accurate data will be. Based on the **Table 4.4** above, some of the data is almost accurate and some is accurate. The less accurate data is from brand A perfume which is 0.648 and the best accurate data is 1 for brand B and D. This is because the speed of light source 850nm is the slowest speed internal reflection and it will take the slowest data response. So some of the data had same reading.

Next is about coefficient of determination (COD), which is to identify the alcohol level in perfume. Based on the **Table 4.4** above, it shows that the data in percentage. Brand B and D has the highest percentage which is 100% followed by brand C which is 78.55%. Brand A has the lowest percentage which is 64.77%.

Next is the sensivity of the FOS. The sensivity means that if the value is near 0.1, the FOS is very sensitive and the fiber optic at its best performance. Based on the **Table 4.4** above, the highest sensivity is brand A which is 0.0001 sensivity followed by brand C which is 0.0003. The lowest sensivity is brand B and D which is 0.

### 4.3.2 Data Analyze Base On Light source 1300nm on four type of perfume.

Linear range is the time use to test the FOS performance against the four type of perfume. The duration 60 minutes was used to find the result and the table below is the outcome of the test.

**Table 4.6:** Data analyze of light source 1300nm test on four type of perfume

| Light Source 1300nm | | | | |
|---|---|---|---|---|
| **Brand** | A | B | C | D |
| **Linear Range (Minute)** | 0-60 | 0-60 | 0-60 | 0-60 |
| **Correlation R** | 0.655 | 0.626 | 0.868 | $2.098x10^{-8}$ |
| **COD (%)** | 65.50% | 63% | 86.80% | >1% |
| **Sensivity** | 0.0001 | 0.0001 | 0.0001 | $3.125x10^{-21}$ |

Correlation R is referring to accuracy data collected from lab experiment. To identify either the data is accurate, the correlation must near to 1.0 as a reference. The nearer the data to the 1.0, the accurate data will be. Based on the **Table 4.5** above, the highest data brand C which is 0.868 followed by brand A which is 0.655 and brand B 0.626. The less lowest or less accurate data is brand D which is $2.098x10^{-8}$.

Next is about coefficient of determination (COD), which is to identify the alcohol level in perfume. Based on the **Table 4.5** above, it shows that the data in percentage. Brand C has the highest percentage which is 86.80% followed by brand A which is 65.50% and brand B 63%. The lowest percentage is brand D which is less than 1%.

Next is the sensivity of the FOS. The sensivity means that if the value is near 0.1, the FOS is very sensitive and the fiber optic at its best performance. Based on the **Table 4.5** above, the highest sensivity is shared by three brand A, B and C which is 0.0001. The lowest sensivity is brand D which is $3.125x10^{-21}$

### 4.3.3 Data Analyze Base On Light source 1310nm on four type of perfume.



Linear range is the time use to test the FOS performance against the four type of perfume. The duration 60 minutes was used to find the result and the table below is the outcome of the test.

**Table 4.7:** Data analyze of light source 1310nm test on four type of perfume

| Light Source 1310nm | | | | |
|---|---|---|---|---|
| **Brand** | A | B | C | D |
| **Linear Range (Minute)** | 0-60 | 0-60 | 0-60 | 0-60 |
| **Correlation R** | 0.96 | 0.994 | 0.866 | 0.926 |
| **COD (%)** | 92.27% | 99% | 75% | 86% |
| **Sensivity** | 0.0014 | 0.003 | 0.0002 | 0.0004 |

Correlation R is referring to accuracy data collected from lab experiment. To identify either the data is accurate, the correlation must near to 1.0 as a reference. The nearer the data to the 1.0, the accurate data will be. Based on the **Table 4.6** above, all four brand of perfume have high correlation value. From this four, brand B has the highest value which is 0.994. The second and third highest is brand A which is 0.96 and brand D 0.926. The lowest correlation value is brand D which is 0.866.

Next is about coefficient of determination (COD), which is to identify the alcohol level in perfume. Based on the **Table 4.6** above, it shows that the data in percentage. Brand B has the highest percentage of alcohol level which is 99% followed by brand A 92.27%. Brand D is the third highest percentage which is 86%. Brand C has the lowest percentage which is 75%.

Next is the sensivity of the FOS. The sensivity means that if the value is near 0.1, the FOS is very sensitive and the fiber optic at its best performance. Based on the **Table 4.6** above, brand B has the highest sensivity compare to other brand which is 0.003. Brand C has the second highest sensivity which is 0.0002 followed by brand D at third highest which is 0.0004. The lowest sensivity is brand A which is 0.0014.



### 4.3.4 Data Analyze Base On Light source 1550nm on four type of perfume.

Linear range is the time use to test the FOS performance against the four type of perfume. The duration 60 minutes was used to find the result and the table below is the outcome of the test.

**Table 4.8:** Data analyze of light source 1550nm test on four type of perfume

| Light Source 1550nm | | | | |
|---|---|---|---|---|
| **Brand** | A | B | C | D |
| **Linear Range (Minute)** | 0-60 | 0-60 | 0-60 | 0-60 |
| **Correlation R** | 0.911 | 0.878 | 1 | 0.829 |
| **COD (%)** | 83.11% | 77.17% | 100.00% | 68.80% |
| **Sensivity** | 0.0003 | 0.0005 | $9.3767x10^{-33}$ | 0.0003 |

Correlation R is referring to accuracy data collected from lab experiment. To identify either the data is accurate, the correlation must near to 1.0 as a reference. The nearer the data to the 1.0, the accurate data will be. Based on the **Table 4.7** above, the accurate data is brand C which is 1 followed by brand A which is 0.911 and brand B 0.878. The less accurate is brand D which is 0.829.

Next is about coefficient of determination (COD), which is to identify the alcohol level in perfume. Based on the **Table 4.6** above, it shows that the data in percentage. The highest percentage is brand C which is 100% followed by brand A which is 83.11% and brand B 77.17%. Brand D has the lowest percentage which is 68.80%.

Next is the sensivity of the FOS. The sensivity means that if the value is near 0.1, the FOS is very sensitive and the fiber optic at its best performance. Based on the **Table 4.7** above, the highest sensivity is brand A and brand D which is 0.0003 followed by brand B 0.0005. The lowest sensivity is brand C which is $9.3767x10^{-33}$.

## 4.4 Summary for the best selected light source for each state based on sensitivity.

This summary presents the best light source by comparing all light source which is 850nm, 1300nm, 1310nm, and 1550nm for all brand of perfume. The selection was based on the highest sensivity of fiber optic sensor during the analyzing period.

**Table 4.9**: The best light source selected based on all brand of perfume

| Brand | Light Source | Range (Duration) | Correlation R | COD (%) | Sensivity |
|---|---|---|---|---|---|
| A | 1300nm | 0-60 | 0.655 | 65.50% | 0.0001 |
| B | 1310nm | 0-60 | 0.994 | 99% | 0.003 |
| C | 1300nm | 0-60 | 0.868 | 86.80% | 0.0001 |
| D | 1550nm | 0-60 | 0.829 | 68.80% | 0.0003 |

**Table 4.8** above show the best light source for each brand by referring to their sensivity. After compare the sensitivity for brand by referring from the table of the light source group, the selected high sensitivity for each brand has been filled in the **Table 4.8**. There were five columns in the table which is brand, light source, range (duration), correlation R, correlation of determination (COD), and sensitivity. The sensitivity is important to prove that the optical fiber can be use as sensor to detect molecule (ethanol) in perfume. Based on **Table 4.8**, show that average light source identify for best performance is 1300nm. Although that 1300nm is not the fastest among all light source, it has the best sensivity for most of the perfume brand. The highest accurate data reading from **Table 4.8** is brand B which is 0.003 accuracies.

As for the highest percentage of coefficient of correlation (COD) is also from brand B which is 99%. The percentage means that the molecule contains in perfume such as response of ethanol that detected by fiber optic sensor. The highest sensivity is brand B which is 0.003. In this situation show that the FOS was response in good condition as a sensor during testing in perfume is carry out. From the analyze, light source 1300nm is the best selection to proceed with concentration detection on ethanol. This is because, light source 1300nm show the highest sensitivity to detect the active molecule in the perfume.

As the conclusion from the **Table 4.8,** the lowest sensivity is from brand D. The molecule of the perfume not too active during test conducted in fiber optic sensor. The best sensivity goes to brand B even the perfume contain high ethanol compare to other material inside the perfume. Although the perfume contains high ethanol, it is safe to use by other people.

# CHAPTER 5

## CONCLUSION & FUTURE WORK

### 5.0 INTRODUCTION

In this chapter will describe about the conclusion for each chapter based on the optical fiber. A fiber optic sensor is a sensor that uses optical fiber either as the sensing element or as a means of relaying signals from a remote sensor to the electronics that process the signals. Fibers have many uses in remote sensing. Fiber optic sensors are also immune to electromagnetic interference, and do not conduct electricity so they can be used in places where there is high voltage electricity or flammable material such as jet fuel. Fiber optic sensors can be designed to withstand high temperatures as well.

In this project the optical fiber was used as a sensor to detect alcohol level in perfume. Hence the title of this project is "*A Development of Fiber Optic Sensors for Detecting Alcohol Level in Perfume (Ethanol)*".

### 5.1 CHAPTER 1

In this chapter was about the introduction of the fiber optic sensor in this project. The objective of this project is to study fiber optic sensor operation, develop fiber optic sensors for detecting alcohol from different brand and analyze the performance of fiber optic. The purpose of fiber optic sensor in this project is to detect the alcohol level in perfume (ethanol) from four different brand. Based on the result, the user can know whether the perfume is suitable to use or not.

## 5.2 CHAPTER 2

In this chapter, was about the literature review. A literature review is a text of a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. The main purpose of this literature review was carried out to avoid any possibility of unwanted during the process of manufacturing fiber optic sensor and carry out experiments in the laboratory. The study was done based on the theory such as the types of fiber optic while references are reliable sources such as articles and technical report. At the beginning of the study was to define and identify the types of optic fiber that is used to this day. There are single-mode and multi-mode. The single mode was used or long distance and multi-mode was for short distance. An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than wire cables. Fibers are used instead of metal wires because signals travel along them with lesser amounts of loss; in addition, fibers are also immune to electromagnetic interference, a problem from which metal wires suffer excessively. The fiber optic has a few light source such as 850nm, 1300nm, 1310nm and 1550nm. Next in this chapter also explain about the advantage and disadvantage of fiber optic. By knowing the advantages and disadvantages of fiber optic, it can avoid failure while doing fiber optic sensor because the possibility of accidentally have given high pressure on core fiber optic during develop process and precautions could be done from the beginning up to the end of the fiber optic sensor developed process. The fiber optic sensor is divided into two part, extrinsic and intrinsic sensor. The extrinsic sensor can be used as sensors to measure strain, temperature, pressure and other quantities by modifying a fiber so that the quantity to be measured modulates the intensity, phase, polarization, wavelength or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. Extrinsic fiber optic sensors use an optical fiber cable, normally a multimode one, to transmit modulated light from either a non-fiber optical sensor, or an electronic sensor connected to an optical transmitter. A major benefit of extrinsic sensors is their ability to reach places which are otherwise inaccessible.

## 5.3 CHAPTER 3

In this chapter was about the methodology. The methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. In other word, the methodology simplify the method used in this in project. To make things easier, flow chart was used to describe the process or flow in this project. First, the process start by proposal and the selection of project title. The title must have certain criteria to get the approval from supervisor. The supervisor must approve the title before continuing the next process. Next, the literature review was conducted based on all the aspects that should be viewed such as the physical fiber optic so that the process of making fiber optic sensor successful. After that, the process was proceeding to research. A further research was made to ensure the best method to be used in FOS. In this section, a suitable technique would be implemented when developing the FOS to avoid any mistake from happening. Next, fiber optic sensor was developed. This process was done in the laboratory by using special equipment such as single fiber optic cable and splicing machine. At this stage, the fiber optic must be handle with care because it easy to damage and fragile. The fiber optic then was tested by using power meter.  Next step, do the experiment and collect the data. The data were collect and a graph was plot based on the data. Then the analysis was made. Finally writing the full report based on all the process.

## 5.4 CHAPTER 4

In this chapter was about the summaries of the analysis that based on data collection from lab experiment. From the collected data, the table and the graph can be produced. The experiment in the laboratory involves the use of four light sources 850nm, 1300nm, 1310nm and 1550nm. The material involved in the experiment is perfume. The time used to study molecules in perfume is 60 minutes. To ensure that the data is accurate, data every 5 minutes was taken from the readings on the power meter. Based on the analysis, the four perfume brands have alcohol (ethanol) content. but that difference is the amount of alcohol in it. Based on observation, a perfume brand B and D has the highest alcohol (ethanol) content. This is because the molecules in the perfume has a high reaction to alcohol (ethanol). Therefore, perfume brand Band D is less suitable for use. Perfume brands A and C have less alcohol (ethanol) content in it but brand perfume C is the best because the content of alcohol (ethanol) in it least in comparison to other brands. As a conclusion, brand C perfume is the most suitable to use.

## 5.5 ADDITIONAL SUGGESTION FOR FUTURE WORK



Perfume is one of the tools that are required by human regardless male or female. However, many users especially Malays who are very concern about the content or material in the perfume. Although some perfume products claims that their products are free from alcohol, but the user is still in doubt about the matter. Therefore, a study was done to ensure that the perfume in the market totally free from any alcohol. a project named as "*A Development of Fiber Optic Sensors for Detecting Alcohol Level in Perfume (Ethanol)*" was carried out. Once the project is implemented, there are several improvements that can be done to ensure that the project was more effective in the future. for example, equipment for use in optical fiber is limited now in UTeM. If the university can add the latest and more sophisticated equipment in the future, then it is possible the results of the experiment would be better. In addition, the atmosphere or a place to test fiber optic is also important in order to ensure more accurate results can be obtained. A place that is spacious and clean from dust can also affect the results of this experiment. This is because optical fiber should not be any dust attached to it. for example, during the splicing process, the connection between both places should be cleared first before making any connection between the two optical fiber. If there is any dust, then the percentage for connecting to them is extremely low.

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# APPENDIX A: GANTT CHART