DENSITY CHARACTERIZATIONS OF ORGANIC SOLVENTS BY AN OPTICAL TECHNIQUE

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

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DEDICATION

In this section is specially dedicated to express my highest gratitude to my beloved parents, family, supervisor, lectures, and friends for all the support, guidance and encouragement throughout completing this project and thesis.

ABSTRACT

The main aim of this project is to design a system that is capable to characterize the density of the organic solvents by using an optical technique. The POF was employed as the sensor instead of the conventional electronic sensor due to less power usage, more cost effective and tend to be thicker than glass optical fibers. The type of organic solvents in consideration is Glycerol, Ethanol and Isopropyl alcohol. Both electrical and optical measurements were taken into account. Arduino Uno is used to read the output data and will be connected with Wi-Fi module for IOT monitoring purpose. The outcome of this project is the identification of different density of the organic solvents produces different refractive index change and the relationship between the value of the refractive index and the output power. In conclusion, when the density of organic solvents gets higher, the light speed through the fiber sensor will decrease thus the output power produced is decrease. Other than that, the most sensitive organic solvent towards the fiber sensor is observed. For this project, the highest sensitivity solution for POF sensor is Isopropyl Alcohol solution. The sensitivity obtained was -61.0022dBm/RIU, -633.671nW/RIU and -11.4706V/RIU. The smallest number of the slope at the graph, the sensitivity is high.

ABSTRAK

Tujuan utama projek ini adalah untuk merekabentuk sistem yang mampu menonjolkan kepadatan pelarut organik dengan menggunakan teknik optik. Serat optik polimer digunakan sebagai sensor dan bukan sensor elektronik konvensional kerana penggunaan kuasa yang kurang, kos yang lebih berkesan dan lebih cenderung menjadi lebih tebal daripada serat optik kaca. Jenis pelarut organik yang dipertimbangkan ialah Glycerol, Ethanol dan Isopropyl alcohol. Arduino Uno digunakan untuk membaca data output dan akan dihubungkan dengan modul Wi-Fi untuk tujuan pengawasan IOT. Hasil daripada projek ini ialah pengenalpastian ketumpatan berlainan pelarut organik menghasilkan perubahan antara nilai indeks bias (RI) dan kuasa output. Kesimpulannya, apabila ketumpatan pelarut organik semakin tinggi, kelajuan cahaya melalui sensor serat akan berkurang, oleh itu kuasa keluaran yang dikeluarkan berkurangan. Selain itu, pelarut organik yang paling sensitif terhadap sensor gentian diperhatikan. Untuk projek ini, penyelesaian sensitiviti tertinggi untuk sensor POF ialah larutan Isopropyl Alkohol. Kepekaan yang diperolehi ialah -61.0022dBm / RIU, -633.671nW/RIU *dan -11.4706V / RIU. Jumlah terkecil dari cerun pada graf, kepekaannya tinggi.*

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LIST OF SYMBOLS AND ABBREVIATIONS

OPM	:	Optical Power Meter
POF	:	Polymer Optical Fiber
IPA	:	Isopropyl Alcohol
PMMA	:	Poly(methyl methacrylate)
RIU	:	Refractive Index Unit

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will discuss the project's introduction, objective, problem statement, and scope of work.

1.1 Introduction

Determination of density of liquids & solvents is of foremost significance in chemical and pharmaceutical industries. Conventional methods for the determination of the characterizations of liquid or solvent, to great extent using a costly and time consuming of setups. A method is proposed to determine the present optical fibers to very great accuracy. The present setup is simple, cost effective and multipurpose by using optical fiber sensor with little effort; the system can be utilized to investigate the relationship between the output powers at different density of the organic solvents.

For this project, polymer optical fiber(POF) is prepared to response the different density of the organic solvents. The reason for selecting polymer optical fiber compared to glass optical fiber is that polymer optical fiber has a large core diameter that results in lower sensitivity to bending loss, thin cladding with lower refractive index, and more durable with greater flexibility and immune to electromagnetic interference[1].

This project utilized the use of a POF to study the sensitivity of the sensor to the different density of the organic solvents. This sensor is capable to detect the output power with respect to the values of density like ethanol, glycerol and isopropyl alcohol. The resolution of the sensor will be observed and compare to previous research. Lastly, the system will be integrated with IOT platform that provide wireless monitoring and detection of various organic solvents. Arduino IDE software will be utilized for processing and the data collected from the sensor will be sent to the cloud services and will be display on Blynk application for the monitoring process.

1.2 Objective

1. To design polymer fiber optic (POF) sensor for organic solvent detection
2. To optically and electrically characterize the performance of various solvents density.
3. To monitor the POF sensor performance via IOT.

1.3 Problem statement

In various experiments, industrial sectors, and congested public places, monitoring of unsafe organic solvents is of particular importance. Organic solvents are widely used in industries such as pharmaceutical industry and food industry[2].

For employees who are continually working with or subjected to these chemicals, monitoring is much more essential as these solvents can have serious health impacts.

Already established methods for their detection are mostly based on electrochemical methods and the electronic sensor. The electronic sensor has limited functionality, and uses an enormous amount of power to operate the sensor[3]. In addition, the electronic sensors are pre-constructed and the sensor sensitivity cannot be adapted. As for electrochemical methods, tedious and expensive procedures involve. Therefore, fiber optic technique is suggested in this venture where the fiber optic detector is more appropriate for severe climate settings.

Current fiber optic sensing system relies on on-site measurement and manual data transmission. As the sensing system becomes one of the major parts in industrial area, automated and wireless system are demanded. With wireless monitoring implementation, the data is more accessible and secure. In addition, cloud services allow the user to access the system remotely without having them to put much effort. It makes the system accessible from anywhere. The real-time data detected will be sent and stored in the cloud for the monitoring process by the user.

1.4 Scope of Work

The project uses multi-mode optic fiber as a probe which is optical polymer fiber (POF). A power source with 650nm of wavelength is chosen for this experiment. The optical sensor is targeted to investigate the performance of the fiber sensor in terms of output power at different density of organic solvents.The sensitivity and resolution of the sensor will be observed from plotted graph.

For the electrical measurement, the fiber optic device is powered by the light source and the other end of the fiber optic device is targeted to the photodiode functioning as the optical signal converter to the electrical signal[4]. Op-Amp is used to amplify the output power signal. The voltage will be measured using a digital multimeter to check the similarity of the output value from the receiver circuit and by using a refractometer, the refractive index of each organic solvent density is measured.

The organic solvents use for this project is ethanol (99%), glycerol (99%), and isopropyl alcohol (IPA) 99%. An Arduino is another main focus behind this project. The inputs of this system are sensed by the optical sensor. The sensor will give an input data and then will be send the data to be read and controlled by the Arduino. From the input data from the sensor, the process of the output will be conducted automatically based on the required condition that being set from the source code. The performance of the solvents will monitor through Blynk application.

CHAPTER 2

BACKGROUND STUDY

This section briefly explained the theoretical background and associated studies on the fiber optic sensor system.

2.1 Optical fiber

Early 70s, development of fiber optic sensor was started and identified with the primary medicinal and mechanical fiber optic endoscopes. Until today, many researchers are studying this technology and are in line with the growing innovation in this fiber optic technology. A study onto the implementation of current optical fiber detectors, for various uses, poses an intrinsic challenge to the estimation of the parameters, in which the custom framework does not fit [5]. Fiber optic technology is indeed a communication system that transmits data using a source of light. The data transferred is mainly electronic data produced by telephone, cable and software systems[6].

Fiber optic is capable of providing low power loss in the information transmission and sensing aspects, with a variety of application, it also has many unique advantages. For carrying more data, fiber optic cables is able to provide more bandwidth. Besides that, fiber optic sensors is more immune to electromagnetic obstruction, multiplexing capacity, distributive detecting and non-intrusiveness, lightweight and high affectability and spark free in comparison with any other sensor [1]. These features make fiber optic sensor a ground-breaking instrument for ecological and mechanical process monitoring.

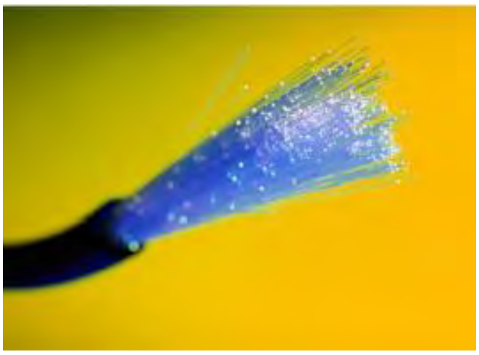

Figure 2.1: Fiber Optic Cable [7]

2.1.1 Structure of Fiber Optic

Optical fiber is a customizable fiber composed of thinner and lightweight high quality glass or plastic. Core, cladding, buffer and jacket are the main structure of the fiber optic[8].

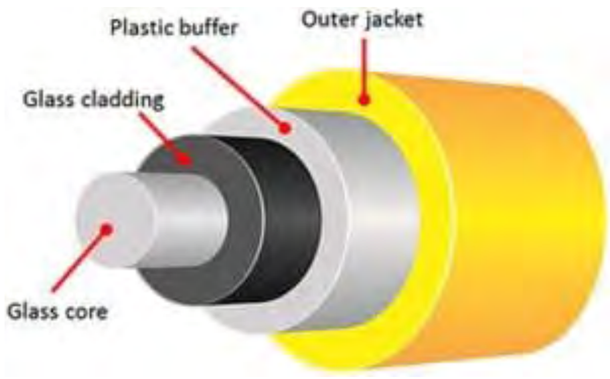

Figure 2.2: Fiber optic structure[9]

Usually the core is produced of glass surrounded by a material coating called a cladding. The light distributed along the core of the fibers. Although, the cladding does not need to be spread along the fiber core, it seeks to reduce scattering from the absence of dielectric on the core surface. It mechanical solidarity to the fiber and shields from engrossing surface contaminants with comes in contact[9].

Usually the core and cladding are produced of glass or plastic. The core's most important element is the refractive index, which is the trigger for light bending through the structure and the pace with which light could pass through the material. Core has a greater refractive index reading than the cladding. This allows light to stay within the fiber layer and not to travel into the cladding[7]. Coating or buffer is a plastic cover used to protect optical filaments toward additional damage. 12wThe buffer is made of plastic material. The buffer is elastic and prevents burns. In addition, the buffer prevents fiber optics from the spread of losses generated from microbends. Microbial happens if the fiber is put on a raw and disrupted surface. If there is no protection, optical fiber is easily damaged due to the small cross-sectional area of optical fiber[10].