

AN ANALYSIS OF DIELECTRIC CONSTANTS OF PHARMACEUTICAL  
MEDICINES USING MICROWAVE RADIATION EXPOSURE

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## **ABSTRACT**

This Final Year Project (FYP) refers to technical work and report writing experience that is relevant to professional development prior to graduation. One of the Universiti Teknikal Malaysia Melaka requirements for the award of Bachelor of Electronic Engineering (Wireless Communication) is that a student should complete his/her Final Year Project (FYP) and report. In order to that, my Final Year Project (FYP) titled “An Analysis of Dielectric Constants of Pharmaceutical Medicines Using Microwave Radiation”. Microwave is a form of energy exists in wave form which travels through free space. Dielectric constants is a reference of characteristic response of material that effect when applied alternating electric field. A pharmaceutical drug also knows as medicine or medication which drug comprise the other major subset of pharmaceuticals, with their source and manufacture being chemical in nature. The purpose of analyzing of dielectric constant of pharmaceutical medicines using microwave radiation is to study the dielectric constant on pharmaceutical medicine at microwave frequency, develop experiment of dielectric constant using pharmaceutical medicine exposure and analyzing dielectric constant of pharmaceutical medicine at microwave frequency. The open-ended coaxial probe was used as a method for complete this project. Then continue with the setup for pharmaceutical samples before do the experiment. There are five samples of pharmaceutical used for this project which is Alucid, Paracetamol, Cloperastine and Chlopheniramine and all sample in a powder form. All the experiment result are recorded and the information will use in analyzing and investigation the effect on pharmaceutical medicines when exposure the microwave radiation.

## ABSTRAK

Projeck Sarjana Muda (PSM) adalah satu usaha dalam menanamkan dan pembagunan sifat professional yang berasaakan kerja-kerja teknikal dan softskill secara menyeluruh. Universiti Teknikal Malaysia Melaka menetapkan syarat dimana pelajar mesti menyiapkan laporan projek dengan sempurna untuk penganugerahan Ijazah Sarjana Muda Kejuruteraan Elektronik (Komunikasi Wayarles). Berasaskan keperluan itu, tajuk projek saya ialah kajian mengenai malar dielectric terhadap ubat apabila didedahkan kepada sinaran microwave. Mikro adalah satu bentuk tenaga yang wujud dalam bentuk gelombang yang bergerak melalui ruang bebas udara. Manakala ubat ialah sejenis bahan yang mengandungi gabungan bahan kimia yang wujud dalam pembuatan sesuatu ubat. Tujuan kajian mengenai pemalar dielektrik ubat-ubatan mengunnakan sinaran mikro adalah untuk membuat kajian mengenai pemalar dielektrik apabila dikenakan pancaran sinaran mikro, membuat ekperiment mengenai pemalar dielektrik pada sinaran mikro dan membuat kajian mengenai pemalar dielektrik apabila dipancarkan sinran mikro. Untuk ekperimen ini, siasatan sepaksi terbuka telah digunakan sebagai satu kaedah untuk menyiapkan projek ini. Seterusnya penyediaan bahan ubat dilakukan dimana semua ubatan dihancurkan dan menjadi serbuk. Setelah bahan ubat disediakan, ekperiment dijalankan. Terdapat lima jenis ubat yang digunakan dalam ekperimen ini iaitu Alucid, Paracetamol, Chloperastine dan Chlopheniramine. Segala keputusan ekperimen direkodkan dan disimpan supaya analisi pemalar dielektrik boleh dilakukan untuk menyiapkan projek ini dan kesan pemalar dielektrik dianalisis apabila dikenakan pancaran sinaran gelombang mikro



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## LIST OF ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
FYP	-	Final Year Project
IEEE	-	Institute of Electrical and Electronics Engineers
FDA	-	Food and Drug Administration
CDRH	-	The Centre for Devices and Radiological Health
R&D	-	research and development
ADS	-	Advanced Design System
VNA	-	Vector Network Analyzer
NDA	-	New drug Application
FCC	-	Federal Communications Commission



## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background**

Microwaves are electromagnetic radiation with a wavelength in free space frequency from 300GHz to 300MHz. The frequencies are the most common using for industrial, scientific, medical and domestic uses for heating purpose are between 915MHz to 2.45GHz where international agreement use different spectrum band for specified power application [1]. In the other hand, microwave technology had been extensively used in the pharmaceutical field for variety application such as the extraction of natural products [2] and pharmaceutical actives [3].

Microwave heating application has been increasing since World War II even though it has been adopted in communication span. The development of the magnetron during the Second World War present was a big challenge in scientific and engineering world to develop industrial application for this technology and adoption of microwave application in the industry sector increase during the decades. In the early nineteen fifties, medical application for microwave was developed which follow the improvement of the development in the design and investigation of material properties. By comparing with other industry sector, the pharmaceutical industry has been a late adopter of microwave technology [4]

Microwaves are a form of energy which apparent as heat through its interaction with materials. The energy directly delivered to the material during molecule interaction with electromagnetic field by the changing of electric fields energy to thermal energy.[20][21][22] The high efficiency of energy changing and reduced processing time is a benefit using this microwave. The manufacturing cost of emerging saving also can be reduced. The energy may be transmitted, absorbed or reflected when microwave directly toward to the material. The capability of the material to microwave processing depends on their capabilities to interact and absorb the microwaves.[24]

The complex permittivity also knows as dielectric properties are related to the ability of a material to interact with electromagnetic energy. In the measurement of dielectric properties, the dielectric constant or permittivity was measured over a wide frequency as a reference of characteristic response of materials that affect when applied alternating electric field. The permittivity was defined using the following equation [1][28][30]:

$$\varepsilon = \varepsilon' - j\varepsilon''$$

$\varepsilon'$  is the dielectric constant which measures how much energy from external field that store in material or reflect the polarization of the material. The ability of a

material to absorb the energy from electric field and exchange of energy to heat is represented as dielectric loss  $\epsilon''$ [31]. The loss tangent expressed as  $\tan \delta = \epsilon''/\epsilon'$  and correspond to the inbound energy that is dissipated as heat in the material.

Dielectric properties are specified to particular physicochemical of the material and it's not a unique quality. Thus, the dielectric properties of materials would be modified or altered during the physicochemical changes process. The interactions between the electromagnetic and material are inherent in the capability of the electric field to polarize the material charges disable this polarization to follow speed changes of the oscillating electric field. There are different kind of the polarization mechanism are possible to present of the external electric field such as electronic polarization due by alteration of electron position around the nucleus, atomic polarization that caused by shift position of the nucleus, an orientation polarization that caused by the reorientation of constant dipoles under the impact of electric field. There are several factors that affect the dielectric properties of material and their interaction with microwave such as the frequency of the microwave, chemical composition of material and moisture content of material.

A pharmaceutical drug also knows as medicine or medication which drug comprise the other major subset of pharmaceuticals, with their manufactured and source being chemical in nature [5]. The purpose of analyzing the dielectric constant of pharmaceutical medicines at microwave frequency is to study the dielectric constant on pharmaceutical medicine at microwave frequency, to develop experiment of dielectric constant using pharmaceutical medicine and analyze dielectric constant of Pharmaceutical medicine at microwave frequency

The methods to conduct this project need lots of literature review based on past studies and experiments which have been conducted, and required a good understanding and knowledge in dielectric properties or dielectric constants at

microwave frequency on pharmaceutical medicines for medical industry. Then determine the method that will be used to conduct the experiment for this project which is a coaxial cable probe. The sample (drug) with added moisture content to the sample (drug) was exposed by the microwave signal at range microwave frequency 400MHz to 4GHz. The electric constant and electric loss of sample (drug) with added moisture content (water) was recorded and will use to investigate and analyzing the effect of the solubility and frequency.

The food and Drug Administration (FDA) United States is responsible for preserving and promote public health by supervision and regulation of the food safety, medicines, electromagnetic radiation, dietary supplement and many more. There is one branch under United States Food and Drug Administration (FDA) which is The Centre for Devices and Radiological Health (CDRH) that responsible for overseeing manufacturing, approval of medical device, and safety of the devices. Certain ranges electromagnetic radiation of radiation safety performance also under responsible of CDRH which radiation safety for non medical device.[6]

The Food and Drug Administration (FDA) has control the manufacture of microwave ovens since 1971. The FDA agency believes that oven that meet the standard are safe to use only meet the standard according to the manufacturing instruction. The Food and Drug Administration (FDA) also responsible to produced electronic product radiation control program authority by the Electronic Product Radiation Control victual of Food Drug and Cosmetic Act. Therefore, FDA enforces and set the standard of electronic product performances to make sure the radiation doesn't bring a hazard that dangerous to public health.

In the pharmaceutical industry, improving Drug research and development (R&D) is a one hard task. Many of the companies need to maintain their sales growth to deliver innovative product to the customer. Companies in pharmaceutical industry need to get the effective strategies that will increase sale and grow the market for remaining the competitive. US Food and Drug Administration (FDA) expect average development time still in 10-15 years. Hence, the cost and development times are unacceptable increase to maintain pharmaceutical growth.[7]

## 1.2 Problem Statement

The microwave technologies have a higher interest in several industry sectors such as rubber, ceramic, food and other industries. Medical applications for microwave were developed early a nineteen-fifteen which has been a late adopter compared to other industry sectors. The problems that I found in microwave application in pharmaceutical industry such as tables form is, an insufficient data sheet on the effects of microwave radiation on pharmaceutical medicines. Based on that reason, I do this project to support and provide some data based on my experiment on few pharmaceutical samples.

## 1.3 Objectives

This study begin on the following objectives:

- i. To study the dielectric constant on Pharmaceutical medicine at microwave frequency
- ii. To develop experiment of dielectric constant using pharmaceutical medicine Exposure.
- iii. To analyze dielectric constant of Pharmaceutical medicine at microwave frequency

## 1.4 Scope

The scope of this study will cover the analysis study the dielectric constant on Pharmaceutical medicine at microwave frequency. The samples will be exposure at range frequency 400MHz to 4GHz where the most frequency applied in medical industry application. Beside that's, there are four common pharmaceutical medicines (Alucid, Cloperastine , Chlorpheniramine , Paracetamol) that will choose and tested where the tablets samples in the powdered form. The effect of dielectric constant on pharmaceutical medicine will tested in term of frequency and moisture level. This experiment will follow the Federal Communications Commission (FCC) rules and base on New Drug Application (NDA) rules and regulations.

## 1.5 Report Structure

The report structure will briefly detail about the all report structure or layout which divide into a few chapter. For this report, there are six chapters that include introduction, literature review, methodology, results, discussion and conclusion chapters.

For the chapter one is an introduction. In this chapter, it will cover briefly about the overview of this project and the background. There is theoretical study that related to this project. There are also covered the problem statement, objective, scope of the project, expected outcome and methodology.

In the second chapter, it will cover the literature review. In this chapter, the information that related to this project was collect by doing the research. There are many resources that will get the information that's important such as from internet, book, journal and etc.

Following that, second chapter contains the literature review or research to get information about this project. In order to get the information which is related,

there will have many resources can gain from, such as internet, journals, books and etc. Based on theory and information about the project, we are comparing some method or technique that will be used in the experiment.

In chapter three, it will cover the methodology of the project. In this chapter, more details about the step, method and process of the experiment will be focused. There are also discussing about the schedules of the project to ensure the project runs smoothly. With this methodology, will be more understanding about the flow of the project and proper planned work scope.

In chapter four, the results are observed based on the experiment that planned. In the other hand, this chapter will discuss about the simulation that used in this project by using the software. By using software, data are record in a table form. The graph, figure and chart will presented for analyzing the result. All the results are produced with proper with the aid of the diagram. Besides that, the output of all table, graph and chart will be discussed in briefly.

Following that, the chapter five will cover the discussion of the project. All the result will elaborate. Based on theoretical fact, all figures and fact are declared with giving reasonable reason. The relationship with experiment and simulation will be discussed details and state by observed and analyzing the result.

The chapter six will cover the conclusion chapter. On this chapter all results, simulation, project finding and conclusion of research implementation that have been used will be concluded. On the other hand, the suggestion to improve the project will be discussed for an enhancement project in the future.

A full report of the Final Year Project is produced by compiling chapter one to chapter six based on fixed rules that set by UTeM for the final year report project. All these chapters are needed to fulfill the requirement by UTeM report structure.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Literature reviews are a progress in read and collect all the informative material such as journal, magazine, article, bulletin and many more, where it used to relate all theoretically, fact and figure which is true and recognize by a specific organization or institution or bodies. Besides that, it's all so mean about the literature review regarding project overall. For this project, I was reviewing some IEEE journals, bulletin, books and internet websites.