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# Human Brain Phantom Modeling: Concentration and Temperature Effects on Relative Permittivity

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**Abstract.** This paper discusses on selecting the most appropriate material for developing human-like brain phantom. It aims to investigate the effect of concentration and temperature to relative permittivity of a sample. This phantom was developed as a human-like brain for tumour detection using microwave signal. Result shows that plant gelatine is a stable and appropriate material for building phantom than agar-agar. A few models were developed based on the proposed ratio of mixture.

## Introduction

This study aims to select the most appropriate material for building a microwave imaging human-like brain phantom using simple material. According to the dielectric properties study [1], the increasing of agar-agar quantity was not applicable due to the increasing hardness of the mixture and hence deviates from the real human brain characteristics. An idea was proposed in this study to mix the element of sugar into gelatine rather than agar-agar. The findings indicate that sugar able to stabilize and optimize the trends of relative permittivity, $\varepsilon_r$ slope [1].

The main disadvantage of using agar-agar as phantom development was exudation of water from agar-agar. The water exudated from the mixture phantom while probing for measurement acquisition. The $\varepsilon_r$ readings from Vector Network Analyzer (VNA) influenced by the exudation water and led to false values. A proposed phantom model development with different material was carried out to solve the exudation problem. New material, gelatine was introduced in this study as the basic material of phantom development. Furthermore, this study also emphasize on the effect of concentration and temperature, ºC to the $\varepsilon_r$ value.

## Literature Review

**Microwave Imaging.** Studies regarding to brain tumour detection using microwave imaging technique were conducted for years in order to find out the simple and costless way to develop a human-like brain phantom. Base on the studies, microwave imaging is a technique used in sensing a given scene by means of interrogating microwaves which has recently proven its usefulness in providing excellent diagnostic capabilities in several areas. Microwave imaging offers comprehensive descriptions of the most important techniques such as short-range microwave imaging [2].

The main interest research in microwave imaging focuses on performance improvement and wide availability of low cost microwave devices, the rapid increase in computational power for calculation of complex electromagnetic problems, the improvement of human body models, and the increased number of reported electromagnetic properties of human tissue [3]. However, most of the researches are focus on detection of breast cancer and few on brain tumour.

**Microwave Imaging Frequency.** According to Ybarra [4], the chosen frequency for microwave imaging must be low enough to provide adequate depth of penetration, but high enough to allow the use of small antenna array elements. The final resolution of the image depends on both the number of antenna array elements and the frequency. In words, image resolution increases with frequency and