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A Novel Tissue-Mimicking Material for Phantom Development in Medical Applications of EIT

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Abstract: A solid Tissue-Mimicking Material (TMM) with adjustable conductivity properties, which can be matched to those of biological tissue, is presented. TMM models of breast fat and gland matching the conductivity of real tissue over the frequency range of 100 kHz–250 kHz are shown. These TMMs are incorportated into an anatomically accurate breast phantom. This TMM will be useful for phantoms used in EIT for clinical research.

1 Introduction

TMMs that have appropriate conductivity over a selected frequency range are used in phantoms, and can be used as pre-clinical, experimental test platforms. Solid TMMs have the advantage of being robust, mechanically and electrically stable over time, and moldable into the anatomy of interest [1]. This paper presents the development of a novel EIT-oriented TMM. This type of TMM, previously used in microwave imaging studies, is composed of graphite, carbon black and polyurethane. Adjusting the ratio of ingredients allows adjustment of the conductivity profile to model any tissue of interest [2-4] Here we present and validate TMMs models of breast fat and breast gland over the frequency range of 100 kHz – 250 kHz. This range is chosen as it matches that of the Swisstom Pioneer, a commercial research-targeted EIT device [5] and that of the impedance analyzer used, the Agilent 4395A. A simple hemispherical aggregate model of the breast combining the fat and gland TMMs is also shown, demonstrating the ease of creating anatomically accurate phantoms with these materials.

2 Methods

Breast fat and gland TMMs, two for each tissue type to cover the range of variability in conductivities inherent to any biological tissue, are made from mixtures of graphite, carbon black and polyurethane, with proportions adapted from [3] and [4]. An impedance analyzer is used to measure the conductivity of the two TMMs over the range 100 kHz – 250 kHz. These values are compared to reference conductivity values for the tissues over the same frequency range [6]. Figure 1 plots the measured and reference conductivities, showing that the range of properties obtained by the TMMs easily cover those of the tissues. Figure 2 shows a simple hemispherical breast phantom created using a heterogenous mixture of the two tissues, in proportions of 30% gland and 70% fat. The two tissues are distributed in discrete locations within the structure. This simple phantom demonstrates the ease of developing more anatomically precise models with this solid, moldable TMM.

3 Conclusions

This study has demonstrated a TMM that can model the conductive properties of biological tissues over the frequency range of interest for EIT medical applications. Further, the material is mechanically and electrically stable for periods of months or years and is easily moldable to create precise anatomical structures. As such, this TMM will be a valuable tool for EIT studies involving biological tissues and organs.

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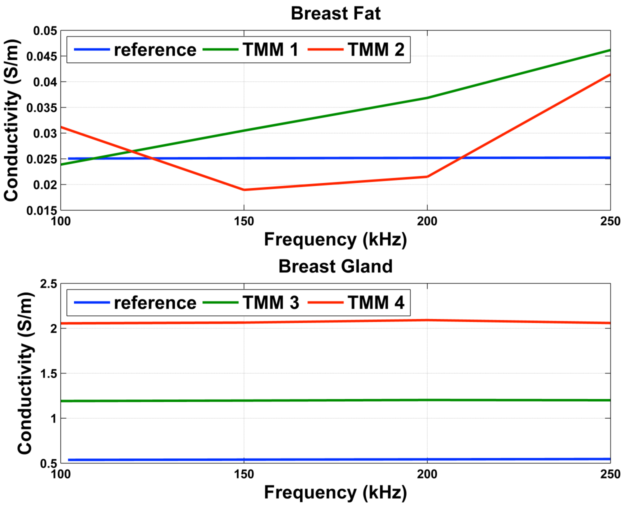

Figure 1: Plots of conductivities for the breast fat (top) and breast gland (bottom) TMM mixtures versus reference values.

Figure 2: Simple hemispherical anatomically accurate breast phantom created using heterogenous mixture of the two tissues.

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