TISSUE-MIMICKING PHANTOM MATERIALS FOR NARROWBAND AND ULTRAWIDEBAND MICROWAVE APPLICATIONS

Lazebnik, M.[1], Madsen, E. L.[2], Frank, G. R.[2] , Hagness, S. C.[1]

[1]Department of Electrical and Computer Engineering, University of Wisconsin, Madison, WI 53706
[2]Department of Medical Physics, University of Wisconsin, Madison, WI 53706

Abstract Submission Form

2004 National Radio Science Meeting

Abstract: lazebnik17655

Date Received: September 24, 2004

Over the past several decades, growing interest and research on the effects of electromagnetic energy on biological tissues as well as on the development of diagnostic or therapeutic applications has resulted in an increased need for biological phantoms that mimic the electromagnetic properties of tissues, particularly at radio and microwave frequencies. Although a variety of tissue-mimicking (TM) material recipes have been published to date that simulate the properties of biological tissues at discrete frequencies, there is currently a need for TM materials for ultrawideband (UWB) applications that enable production of heterogeneous and anthropomorphic phantoms.

We propose a solid gelatin-based TM phantom recipe that simulates the dispersive dielectric properties of a variety of biological tissues at a wide frequency range (500 MHz to 20 GHz). The TM muscle is created from primarily gelatin and water. The TM fat is made using the same gelatin material, except that, prior to congealing, it is combined with safflower oil and a surfactant in a volume ratio of 1:4 (resulting in an 80% oil-in-gelatin dispersion). The dielectric properties of the materials are controlled by varying the volume percent of the oil. Since the TM muscle and the gel matrix surrounding the oil droplets of the TM fat have the same composition, these materials can be placed in direct contact with no risk of diffusion of the solvent or solute. Thus, a critical property of this recipe is the ability to create heterogeneous configurations with long-term stability of mechanical and electromagnetic properties.

Our results indicate that the phantom compositions with very little oil (0-10%) are appropriate materials for mimicking high-water-content tissue, such as muscle or malignant breast tumors, below about 8 GHz. Above 8 GHz, however, the permittivity of the TM material will be somewhat lower than desired. Compositions with a high percentage of oil (70-80%) are appropriate materials for mimicking low-water content tissue, such as fat, over the entire frequency range reported. By decreasing the volume percent of the oil, we can create materials with intermediate dielectric properties spanning these two bounds. This recipe is also very well suited for a narrowband application, since the dielectric properties of the materials can be tuned precisely by appropriate choice of the volume percent of oil.

1. (a) Mariya Lazebnik
ECE Department
1415 Engineering Drive
Madison, WI
53706 USA
lazebnik@cae.wisc.edu
(b) 608-265-0651
(c) 608-262-1267

2. K - Electromagnetics in Biology and Medecine

3. (a)

4. C - Contributed Paper

5. This paper is for the URSI K special session entitled "Human Body Phantoms for Wideband EM Interactions"