MODELING THE EFFECTIVE DIELECTRIC PROPERTIES OF BREAST FAT TISSUE

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Variation of the dielectric properties of biological tissues is an important area of study because the dielectric property is an important indicator of tissue health. The concentration and distribution of water dominates the dielectric permittivity of the tissue at any location. This thesis analyzes the dependence of the permittivity of biological tissues on water distribution as well as content. Water distribution is another factor that explains the differences that have been found in the dielectric properties of different samples of fat having the same water content. In this study, we consider different models of water inclusions within a dry fat medium. The effective complex permittivity of the mixture is computed for different shapes of the inclusions and varying water percentage. The T-matrix multiple scattering theory was introduced years ago to evaluate the effect of inclusions in a host dielectric material when the interactions with electromagnetic radiation are of interest. Multiple scattering theory is a good method to predict the effective complex permittivity of a heterogeneous material when either the concentration or the size of the suspended constituents is large. It has been very successful in describing the macroscopic behavior of a large number of natural and artificial composite materials, but it has not been applied to model the dielectric permittivity of biological tissues. This thesis proposes an application of this theory to fat/water mixtures with emphasis to explain the dependence of the complex permittivity on water content as well as on water distribution. The effective permittivity, obtained for different shape of water inclusions through the multiple scattering theory, is compared with experimental data from literature. A full 3-D finite element simulation was undertaken of the full breast model using the properties from our computed database. The high conductivity of the epidermal layer results in a very large front surface mismatch. This is a great experimental challenge that must be overcome if microwave imaging is to become a practical tool for the early detection of electrically small breast tumors. A further experimental work is still needed. The presented theoretical models in this thesis are a positive step toward developing and enhancing new reliable models for biomedical diagnostics.