Multiphysics simulations of ex vivo microwave hyperthermia on different biological tissues

Guoyan CHEN, Nour-Eddine Belhadj-Tahar and Hamid KOKABI
Sorbonne Universités, UPMC, Univ Paris 06, UR2, L2E
(Laboratoire d'Electronique et Electromagnétisme), F-75005, Paris, France

Introduction:

This paper presents electromagnetic and thermal simulations using COMSOL Multiphysics with 2D axisymmetrical finite–element method for a percutaneous microwave hyperthermia system with ex–vivo experiments on different biological tissues. It shows the temperature variation and distribution in the biological tissues submitted to an open ended coaxial cable as the microwave percutaneous applicator.

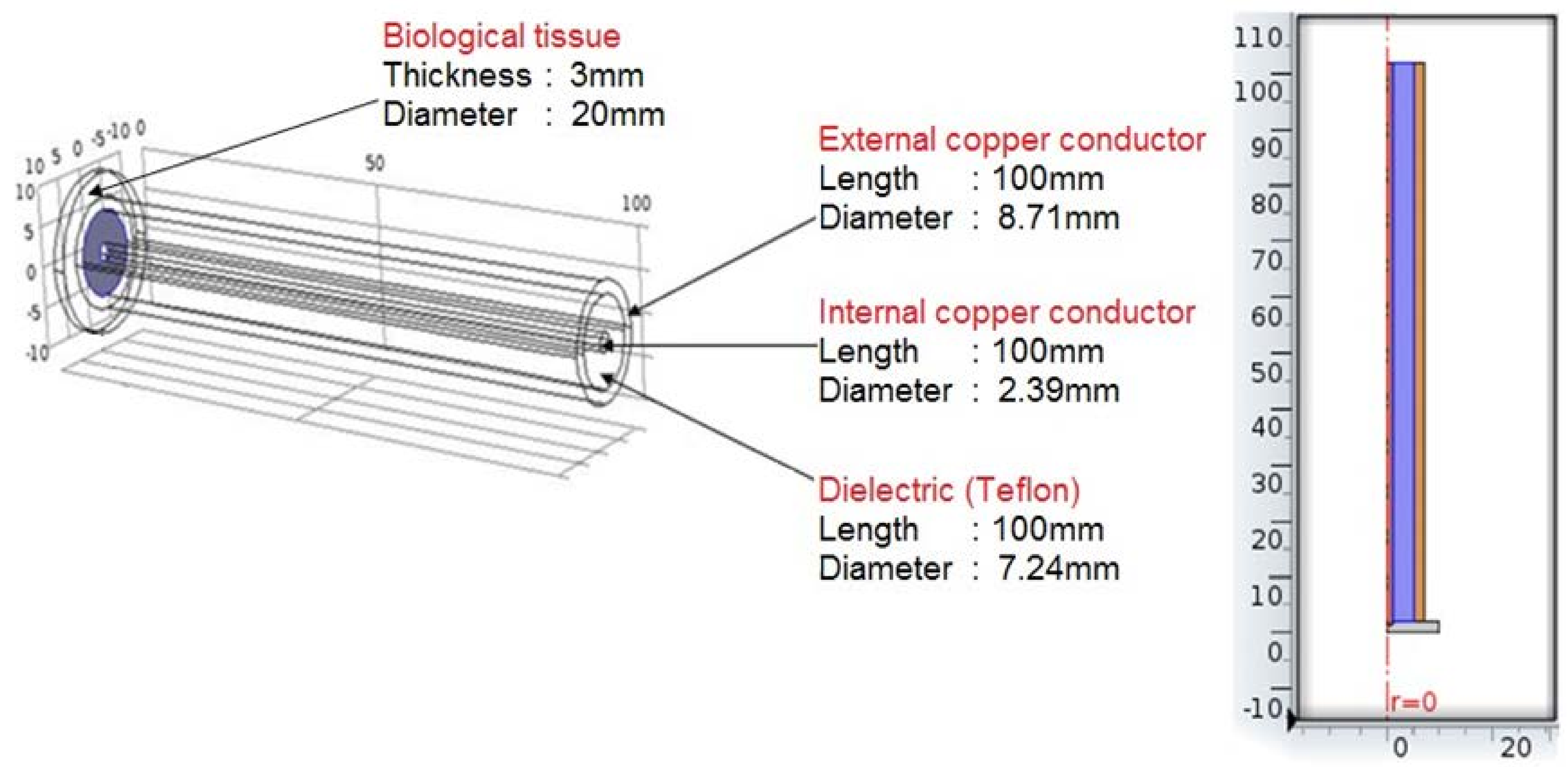

Figure 1. 3D and 2D axisymmetrical views of coaxial cable applicator in contact with biological tissues.

Computational Methods:

Three types of heat transfer mechanism within the tissue should be considered for the microwave hyperthermia simulations:

Thermal conduction : thermal conductivity k of the biological tissue.

Thermal convection : *h* normally is 5W / m².K for ex vivo experiments [1].

Thermal surface–to–ambient radiation for interactions with the surrounding environment.

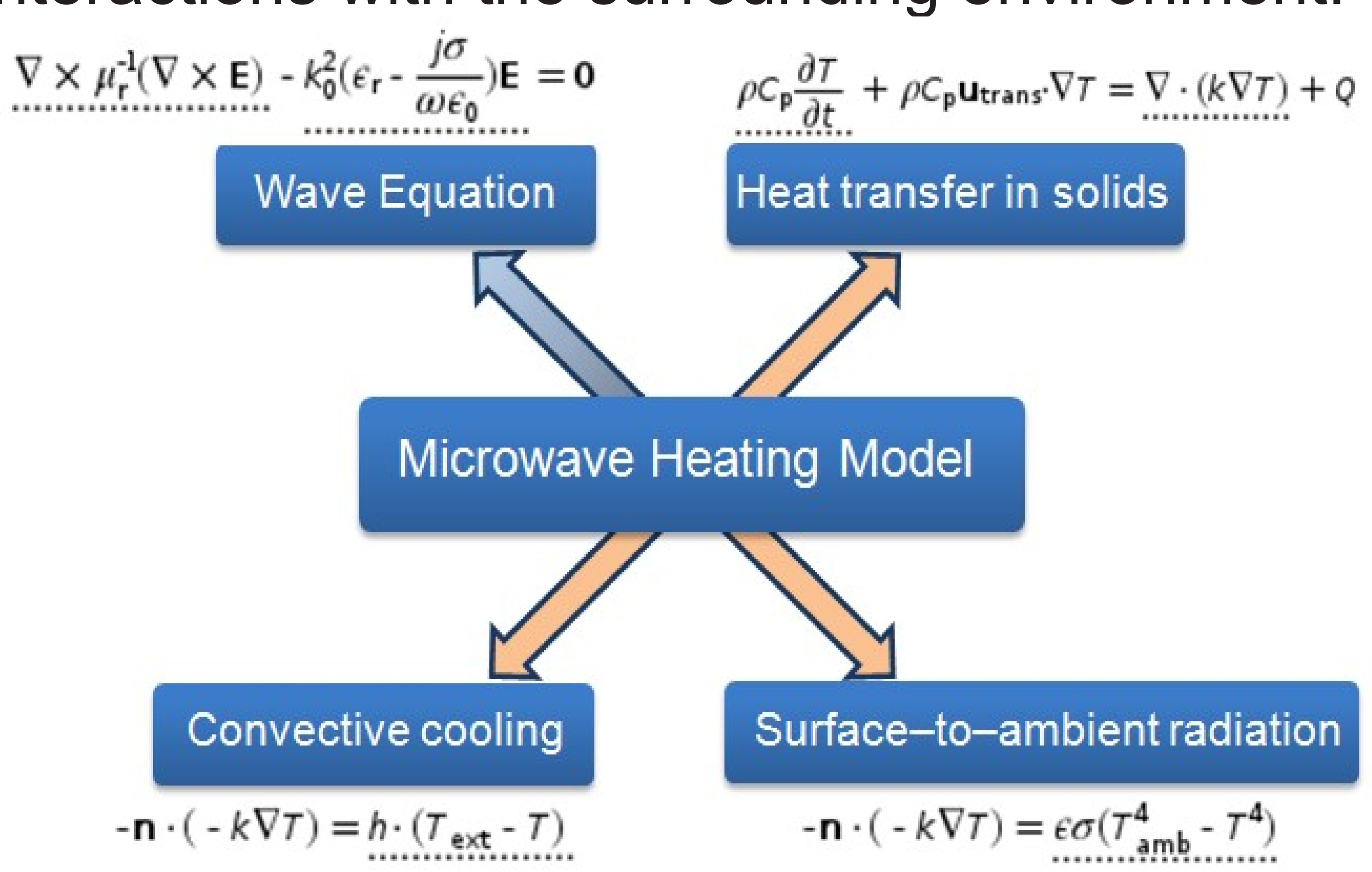

Figure 2. Conditions for microwave heating model for simulation of ex vivo microwave hyperthermia [2].

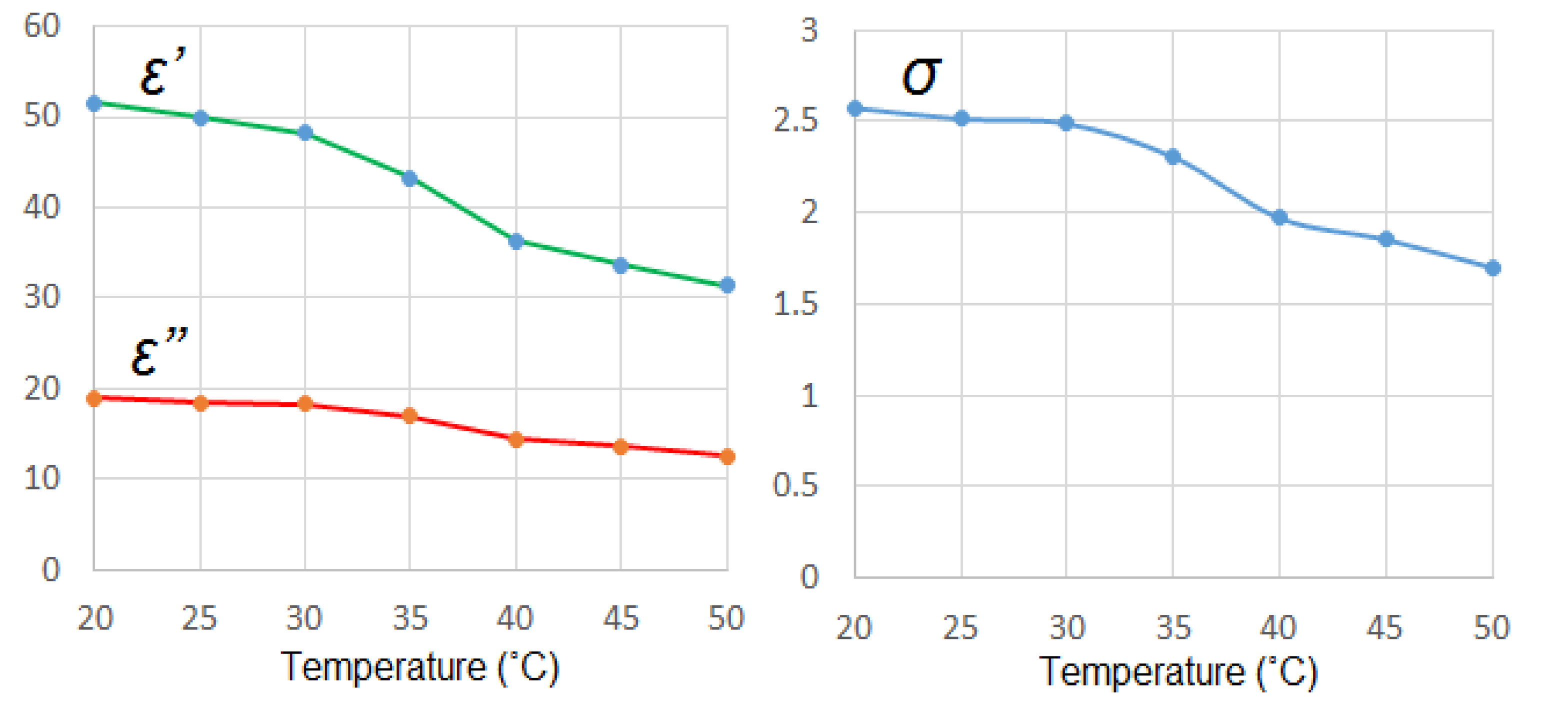

Figure 3. ε'(T) and σ(T) of pork obtained by dielectric microwave characterization experiments.

Constant values of relative permittivity and electric conductivity are replaced by measured values of ε'(T) and σ(T) as a function of temperature (e.g. chicken meat sample) in order to be as close as possible to the practical experiments.

Results:

Spatial distribution of temperature inside the tissue is also obtained by COMSOL. In fact, the highest temperature (Tmax) appears inside of the tissue. The temperature which is measured by the sensor is lower than Tmax.

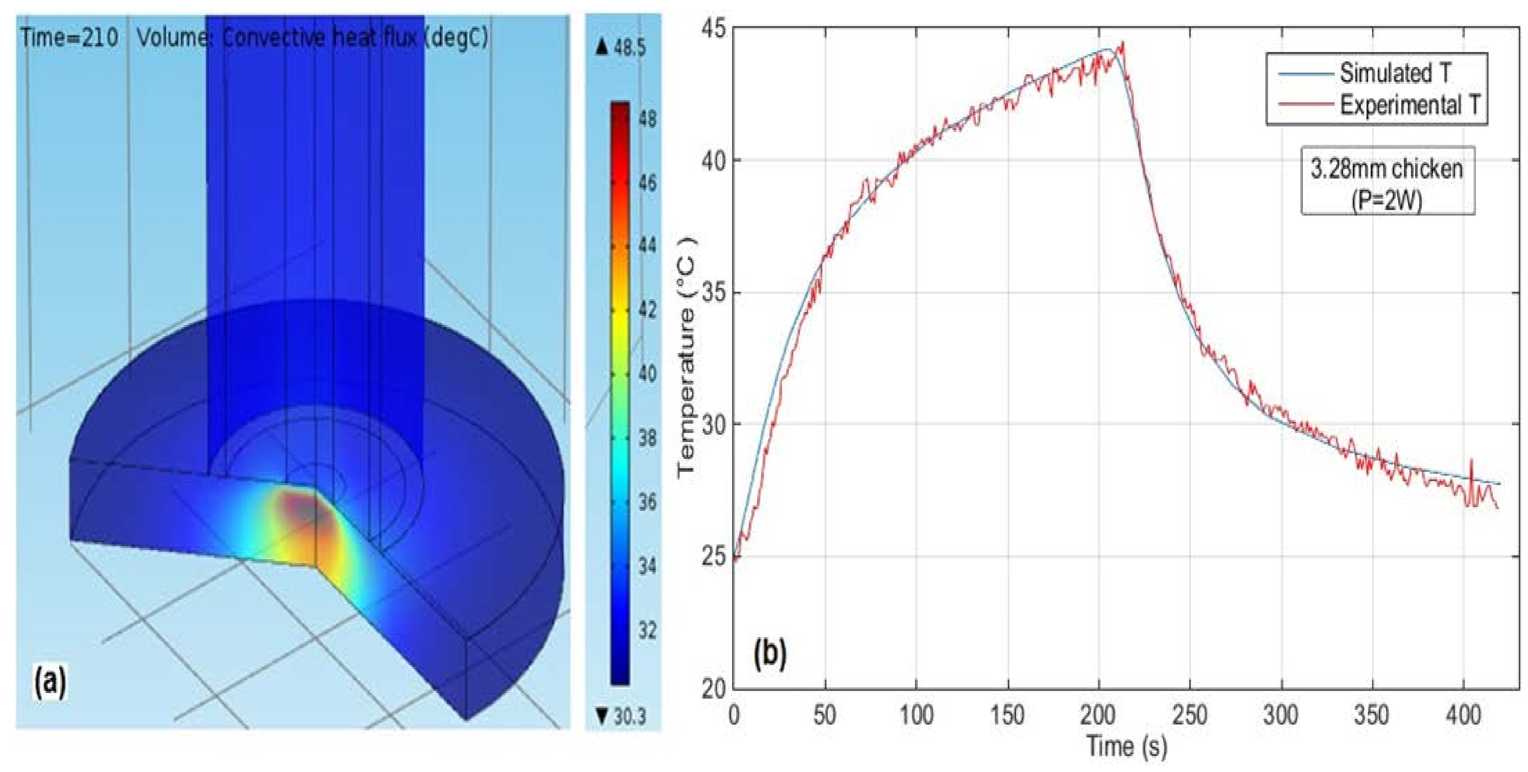

Figure 4. (a) Spatial distribution of temperature inside a 3mm thick chicken meat sample, (b) Comparison between experimental and simulated temperature variations for this sample submitted to P=2 Watts.

Conclusions:

The variation of temperature in different tissues measured by an infrared sensor corresponds well with the simulated results. Measured values of temperature variations of ε'(T) and σ(T) are used in the simulations, to reflect the practical experiments.

References:

1. http://www.engineeringtoolbox.com/convective-heat-transfer-d_430.html
2. https://www.comsol.fr/model/download/326361/models.rf.microwave_cancer_therapy.pdf

Excerpt from the Proceedings of the 2016 COMSOL Conference in Munich