URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

A model for the interactions of electric and electromagnetic fields with biological objects

Lluis M. Mir
Vectorology and Anticancer Therapies, UMR 8203, CNRS, Univ. Paris-Sud, Gustave Roussy, Université Paris-Saclay, France; luismir@cnrs.fr

The effects of short and intense electric pulses on cell membranes are well identified. The delivery of these electric pulses, termed electropulsation, is a very robust phenomenon that results in changes of the cell membrane permeability that are known as electroporation or electropermeabilization. Electropulsation has a number of applications in biology and medicine and in the industries of food and environment. Electroporation is already used in human and veterinary clinics, particularly in the frame of an antitumor approach termed electrochemotherapy. Still, controversies on the changes affecting the cell membrane after the electric pulses delivery were/are a continuous discussion topic amongst the experts in the field.
A model of the interaction of the electric fields with cells has been built to explain the various steps and kinetics of the observable effects of these pulses. It has been numerically developed using molecular dynamics and experimentally validated using various approaches. It includes the electrical effects calculated from the Maxwell equations, but also chemical modifications of the membrane molecules permitted by the reorientation of the dipoles and the redistribution of the molecules at each side of the membrane, and even in the membrane. Such changes can be tracked by a number of experimental techniques including linear and non-linear optical methods, mass spectroscopy, classical fluorescence microscopy as well as Terahertz spectroscopy. Interestingly, these techniques comprise label-dependent as well as label-free approaches that allow to investigate the events occurring at the cell membrane level. Present studies are seeking to extend this model to understand the interactions of electromagnetic fields with living objects, in particular with the membranes of the cells.