Modeling Electric Field Stimulation of Single Cardiac Cell: Electrodiffusive Model Approach

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The cable (based on analogy between an electric cable and a cell) and the electrodiffusive models (based on Nernst-Planck and Poisson equations) are two models in use in literature for the study of electric behavior of cells. Despite being justified by experiments, the cable model does not fundamentally consider spatial variations in ionic species concentrations (i.e. the diffusive fluxes). This limits the predictive accuracy of the model for the transmembrane voltage changes that occur during cell stimulation.

In this work, the electrodiffusive model is used to study the external field stimulation of a single cardiac cell. The membrane, because of its physiology (biological proteins) is assumed to act both as a capacitor and an electrode at which bioelectrochemical reactions occur and the kinetics are expressed using Hodgkin-Huxley formalism.
The results obtained by the electrodiffusive method are compared to those of cable model with respect to the diffusive and ionic species concentration variation within the cardiac cell.