CADFEM Consulting

Electrically Driven Ion Migration within Biological Tissue

Transient Electric Field Analysis Incorporating Materials with both Conductive and Dielectric Properties

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Task

The deposition of active pharmaceutical ingredients on skin or mucosa surfaces or their migration into biological tissue, respectively, can be enhanced by the application of a driving electric field. This process is known as "Iontophoresis".

The efficiency of an iontophoretic application with respect to various regions of biological surface had to be studied for Braun GmbH, a well-known supplier of consumer products and small appliances.

Solution

The migration of ions of the active ingredient through the carrier substance and the tissue follows the electric current density vector field.

However, biological tissue is not just an electric ion conductor but shows significant dielectric permittivity, too. Therefore a surface charge builds up at the boundary between tissue and carrier substance. In case of a pulsed driving voltage the electric current density will contain components required for charging and discharging.

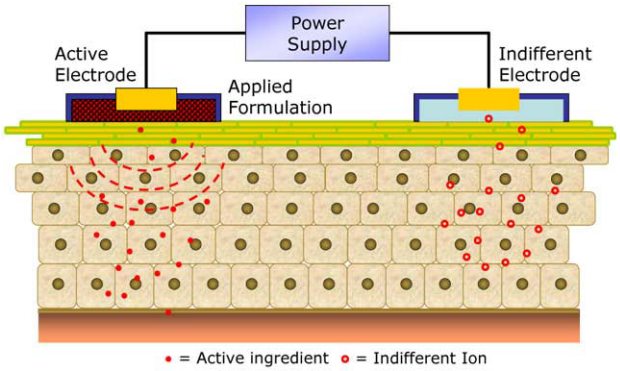
Within the ANSYS FEM-model both properties, i.e. conductivity and dielectric permittivity, are defined for each material in one and the same simulation. The transient simulation returns the time-dependent current density vector field including the components required for boundary (dis-)charging.

The effective ion flow impacting the 3D skin surface is finally obtained by time-averaging the current density at each point of the boundary.

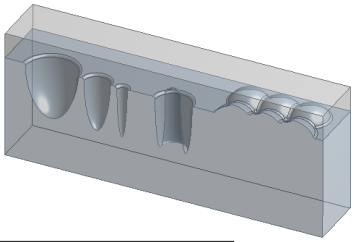
Customer Benefit

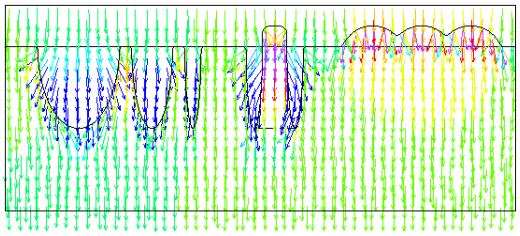
The simulation results reveal optimum operating parameters for moving the active ingredient to the desired location in the tissue:

- Evaluating the migration rate especially into pores of different size
- Understanding the effect of various dynamic signal parameters like signal shape and frequency on the migration rate;
  ➔ optimization of the driving signal
- Optimizing the shape and size of the active electrode

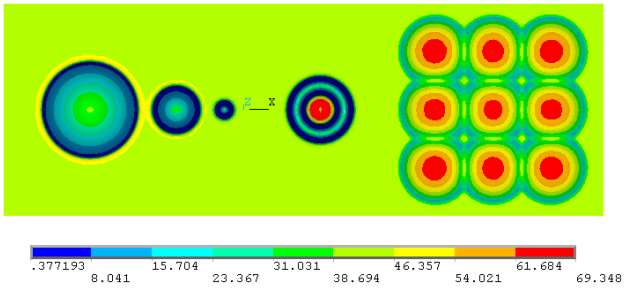


Principle of moving active pharmaceutical ingredients into biological tissue by an electric field ("Iontophoresis")





3D model of an uneven skin surface with schematic pores of different shape and size; vector field of electric current density



Effective time-averaged ion flow impacting the skin surface

Figures Courtesy of Braun GmbH