Numerical Simulation of Chamber Design for Pulsed Electric Fields Processing of Wet Olive Pomace

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Abstract

Application of pulsed electric fields (PEF) is well known in the food industry as an advance technology for mass transfer improvement. A new potential adaptation area of PEF could be extracting a valuable antioxidant called polyphenol from wet olive pomace (WOP) which is a by-product of olive oil production. The modelling includes the PEF effects on the WOP which is flowing through a properly configured chamber. In the research two kinds of PEF chambers are examined: one is the collinear and the other is the coaxial. The extraction process is a very sensitive treatment, because above a certain electric field value electroporation could occur, therefore the form of the chamber's design has significant role. The aim of the research is creating a comparison according to the collinear and coaxial chambers, which realizes by pre-defined performance indicator. The performance indicator essentially evaluates the uniformity of the treatment; it is specified by the averaged specific energy. The data for the performance indicator's assay are exported from the appropriate COMSOL Multiphysics® software post processing function as well as the performance indicator functions were implemented in MATLAB®. Since the WOP is a rarely used as raw material in studies and there were no found any properties for it in the literature, some temperature dependent measurements were necessary. In the comparison of the two PEF chambers the power consumption and the flow rate requirement were the same.

The primary objective of the simulation is examining the resulting electric field and the temperature distribution in both kinds of chambers besides WOP's flowing. The final model is relatively complex: three types of physical interfaces are coupled. First of all there is laminar flowing through the chamber, which is coupled by two other interfaces, which are electric currents and heat transfer. The measured material properties of WOP were defined by temperature dependent interpolation functions. There were some approximations during the simulation, like WOP is a non-Newtonian flow. Fortunately the Reynolds numbers in both chambers are so low - actually WOP is creeping in the chamber - that the process could be handling like a simple laminar flow. Another simplification of the model that it is time dependent and pulsing appears only as external heat source.

In this study the electric field and temperature distribution are examined by finite element method (FEM) models for collinear and coaxial PEF chamber design besides flowing WOP through the chambers. The power consumption and the flow rate for a given term are fixed in both cases.

Performance indicator is determined by the help of the FEM results and containing the means of the specific energy received by each particles travelling along the chambers. The indicators are compared for both collinear and coaxial chambers helping to decide about the choosing of the more appropriate chamber design.

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Reference

1. S. Schroeder, R. Buckow, K. Knoerzer: Numerical simulation of pulsed electric fields (PEF) processing for chamber design and optimisation; Seventh International Conference on CFD in the Minerals and Process Industries, CSIRO, Melbourne, Australia, 9-11 December 2009
2. H. Jaegger, N. Meneses, D. Knorr: Impact of PEF treatment inhomogenity such as electric field distribution, flow characteristics and temperature effects on the in activation of E. coli and milk alkaline phosphatese; Innovative Food Science and Emerging Technologies 10 (2009) 470-480

Figures used in the abstract

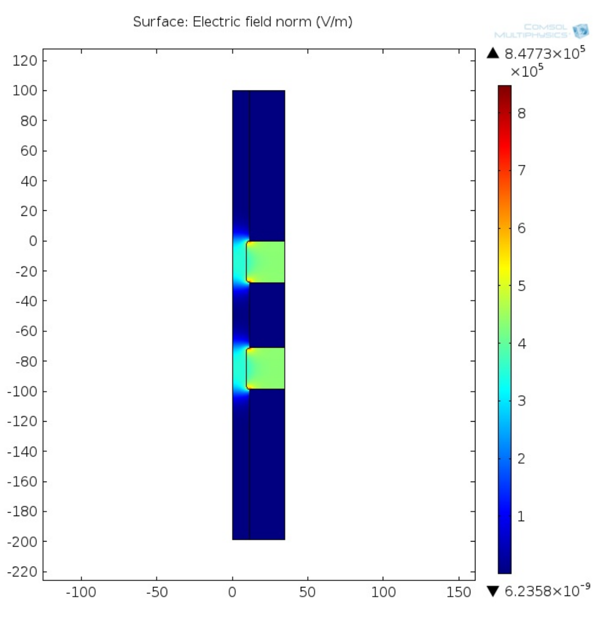

Figure 1: Electric field norm for colinear chamber.

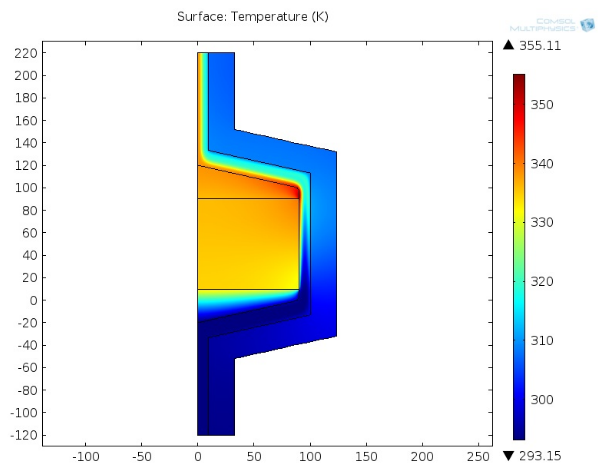

Figure 2: Temperature distribution for coaxial chamber.