FREEZING UNDER STATIC ELECTRIC FIELD

Prof. Alain LE BAIL

Contact: alain.lebail@oniris-nantes.fr

1ONIRIS – GEPEA - UMR CNRS 6144 Nantes France

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FREEZING UNDER ELECTRIC FIELD
External electric field applied to a real medium → a current flows

\[ \vec{D} = \varepsilon \cdot \vec{E} \]
ELECTROFREEZING via strong electric field

EXPERIMENTAL SETUP

SYSTEM DESIGNED AT ENITIAA

- sample holder
- measurement cell
- aluminium electrode
- DC generator
- optical fiber
- real-time data acquisition
- plate-to-air heat pump
- temperature controller
CFD EVALUATION OF EFFECTIVE ELECTRIC FIELD IN THE SAMPLE (comsol)

Dielectric permittivities: air = 1, container (plastic) = 3.6 and water = 80

**EXPERIMENTAL SETUP**

HT Generator

1 cm

PLASTIC (CONTAINER)  SAMPLE 1.6 ml

PELETIER ELEMENT (Metalic surface)

8 cm x 8 cm

Effects of an electrostatic field on ice nucleation
Michel Havet, Marta Orlowska & Alain LeBail - BFE 2009 - Compiègne, France, October 22-23 2009
CFD EVALUATION OF EFFECTIVE ELECTRIC FIELD IN THE SAMPLE (comsol)

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ELECTROFREEZING of distilled water

Experimental procedure:
1. pre-cooling of the water sample (1.6 ml) at 1 °C
2. calibration of the optical fiber
3. cooling of the sample up to -16 °C under applied high voltage conditions

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>Electric field (V/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>$1.0 \times 10^6$</td>
</tr>
<tr>
<td>5</td>
<td>$2.5 \times 10^6$</td>
</tr>
<tr>
<td>10</td>
<td>$5.0 \times 10^6$</td>
</tr>
<tr>
<td>12</td>
<td>$6.0 \times 10^6$</td>
</tr>
</tbody>
</table>
Temperature profiles obtained under different electrostatic field conditions.

WATER

- 2kV => 1.0×10^6 V/m
- 5kV => 2.5×10^6 V/m
- 10kV => 5.0×10^6 V/m
- 12kV => 6.0×10^6 V/m
ELECTROFREEZING: PORK MEAT

NO FIELD

12 kV
6.10^6 V/m

100µm

Ref: Le-Bail et al. Unpublished
MSc THIAM – ONIRIS – 2011
**ELECTROFREEZING: PORK MEAT**

![Figure](image-url)

Figure

Micrograph images of frozen pork tenderloin transversal cuts under different magnitude static electric fields. (a) Fresh meat, (b) 0 kV, (c) 3 kV, (d) 6 kV, (e) 9 kV, (f) 12 kV.

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ELECTROFREEZING: references

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Le-Bail, A., M. Orlowska, and M. Havet. Possible interest of electric field during food freezing; a review on electrofreezing. in 1st IIIR Conference on Sustainability and the cold chain. 2010. Cambridge, UK 29th, 30th and 31st March 2010 International Institute of Refrigeration Paper 240

Le-Bail, A., M. Orlowska, and M. Havet. Electrofreezing; a review on the potential interest of electric field during food freezing. in New Challenges in Food Preservation. 2009. Budapest Marriott Hotel, Budapest, Hungary,:11th - 13th November 2009 ELSEVIER