



**HAL**  
open science

# Conception of an ohmic heating reactor to study the kinetics of chemical reactions at high temperature in liquid food products

Stéphanie Roux, Mathilde Courel, Jean-Pierre Pain

► **To cite this version:**

Stéphanie Roux, Mathilde Courel, Jean-Pierre Pain. Conception of an ohmic heating reactor to study the kinetics of chemical reactions at high temperature in liquid food products. First European Food Congress: Food Production, Nutrition, Healthy Consumers, Nov 2008, Ljubljana, Slovenia. EFFoST 2008. mnhn-03922902v1

**HAL Id: mnhn-03922902**

**<https://mnhn.hal.science/mnhn-03922902v1>**

Submitted on 4 Jan 2023 (v1), last revised 9 Jan 2023 (v2)

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Conception of an ohmic heating reactor to study the kinetics of chemical reactions at high temperature in liquid food products

Stéphanie ROUX<sup>a</sup>, Mathilde COUREL<sup>b</sup>, Jean-Pierre PAIN<sup>a</sup>



<sup>a</sup> UMR QualiSud, Université Montpellier II, Place Eugène Bataillon, 34095 Montpellier, France  
<sup>b</sup> UMR 1145 Génie Industriel Alimentaire (AgroParisTech, Cemagref, INRA), 1 av. des Olympiades, 91744 Massy, France  
 stephanie.roux@univ-montp2.fr ; mathilde.courel@agroparitech.fr ; jppain@polytech.univ-montp2.fr



## A BATCH OHMIC REACTOR

### Objective

→ Development of a tool to study the kinetics of chemical reactions in high temperature short time (HTST) thermal treatments of liquid food products

### Specifications

- Reach sterilization temperatures above 100 °C without boiling by maintaining pressure
- Produce reliable kinetic data during very short treatment times
- Guarantee a thorough control of the temperature because of strong thermal dependence of the chemical reactions

### Principle of Ohmic Heating

The product is placed in an isolated treatment cell closed by two electrodes connected to an electricity generator. An alternative electric current circulates through the product which acts like an electrical resistance. The whole volume of the product is thus heated up according to Ohm's law. The homogeneity of the thermal treatment is achieved by homogenizing:

- the electric field → parallel electrodes
- the velocity field → batch configuration
- the product → liquid products

### Reactor conception

- Treatment cell: 100 mL ; ULITEM
- Electrodes: DSA coated titanium
- Tension generator: 50 Hz; 0 – 320 V; 0 – 20 A
- Thermocouples: type K
- Labview program for recordings
- Thermal regulation: simulator control and data acquisition
- 5 sampling valves of 15 mL each

### Thermal treatment in 3 steps

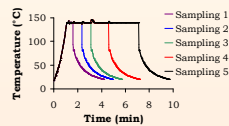
1. **Heating** : from 50 °C to sterilization T (100 to 140 °C)
2. **Holding** : sterilization temperature is maintained
3. **Cooling** : cooling from sterilization T to 25 °C

### Sampling

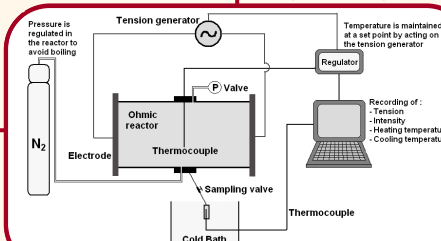
5 samples can be taken during one thermal treatment, during heating or holding steps.  
 Sampling time can be very short: 5 seconds.  
 Sampling may produce an artifact: in some cases an increase in temperature can be observed; it stays very brief and the impact on the whole thermal treatment can be neglected.

**Example: ohmic treatment of a semi-skimmed milk at 140°C with five sampling**

	Temperature	Time
<b>Heating</b>	20 – 140 °C	S1: 0.5 min
		S2: 1.25 min
		S3: 2.0 min
<b>Holding</b>	139.6 ± 1.1 °C	S4: 3.5 min
		S5: 6.0 min
<b>Cooling</b>	140 – 100 °C	1 sec
	100 – 20 °C	2.5 min



Schematic representation of the ohmic heating reactor



## PRELIMINARY MEASUREMENTS

### Electrical conductivity of the sample

Electrical conductivity  $\sigma$  (Siemens/m) is a key variable in Ohm's law, which determines the aptitude of the product for ohmic heating:

$$U = R \cdot I = \frac{e}{\sigma \cdot S} \cdot I$$

The conductivity can be measured experimentally by heating the product in the ohmic prototype and recording temperature, tension and intensity

- $\sigma < 0.05$  S/m and  $\sigma > 100$  S/m is not appropriate for ohmic heating
- $0.05 < \sigma < 100$  S/m is optimum for ohmic heating

### Temperature homogeneity in the reactor

The thermal homogeneity of the reactor has been checked by recording the temperature of 5 thermocouples placed at different distances from the center of the reactor.

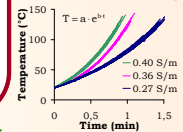
A dispersion of maximum 2 % around the average value of the targeted temperature shows a good thermal homogeneity of the reactor.



Examples :

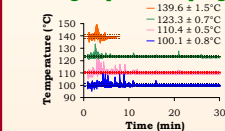
Mean temperature (°C)	Dispersion between the 5 thermocouples
100.1 ± 0.4	1.3 %
110.1 ± 0.4	1.1 %
120.1 ± 0.4	1.0 %
130.0 ± 0.4	1.1 %
139.5 ± 0.4	1.5 %

### Heating step



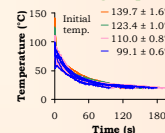
The heating kinetic can be adjusted by an exponential equation with a relative standard deviation of ± 3 % for a and b, for given initial conductivity and electrical power inlet and independently of the initial and final temperatures.

### Holding step with sampling



The holding step is also very reproducible. The results presented for each temperature level are average of 3 to 20 trials. Sampling causes temperature artifacts which appear to be non significant as relative standard deviations do not exceed 1 %.

### Cooling step



The cooling step is very fast and is independent on initial temperature: it takes about 1 second for all samples to cool down to 100°C and several minutes to decrease to 20 °C.

## THERMAL TREATMENTS

## REPRODUCIBILITY

## CONCLUSION AND PERSPECTIVES

The ohmic reactor allows reaching a large range of temperatures – ambient to 140°C – during a wide range of times – 5 seconds to several minutes – thus covering pasteurization to UHT sterilization conditions. The thermal history of the product has been proven to have a good reproducibility. The sampling device combined to a very efficient cooling should allow producing reliable experimental data for studying the kinetics of chemical reaction under HTST conditions.