
Final Report

Project reference: 26
Applicant's name: Jürg Fröhlich
Project title: Thermosensor protein GrpE of the heat shock protein Hsp70 system as target for high-frequency electromagnetic fields

1. State of Research.

1.1 Research activities performed, milestones and deliverables accomplished

Technical:

An experimental set-up allowing for simultaneous recording of the circular dichroism (CD) signal during exposure to electromagnetic fields (frequencies: 10 – 2.000 MHz; amplitude range: 50 – 1.500 V/m) of microbiological solutions has been realized. The setup allows for reproducible experiments under controlled conditions. Temperature and field strength is continuously monitored. The protein solution can be thermostated in the range from 15 up to 95 °C. The setup has been validated by numerical and experimental means.

Biological experiments:

The following experiments have been carried out:

- determination of best suited concentration of buffer solution achieving as low as possible losses within the buffer solution (reducing ion concentrations)
- experiments using 10 µM (monomer concentration) GrpE for the assessment of variations
- determination of achievable measurement accuracy under different conditions (integration time, ramp-up time for temperature, etc.)
- determination of experimental parameters achieving the best possible reproducibility of experiments
- assessment of long-term stability of GrpE applying repeated temperature cycles
- setting up a frame of reference for investigating interactions of electromagnetic fields with biological macromolecules in real time regarding conditions of sample volume versus induced temperature changes versus field strength within sample and time constants of different thermodynamic processes (heating, diffusion, etc.) and protein dynamics
- examination whether high-frequency electromagnetic fields at specific frequencies shift the conformational equilibrium in GrpE

A journal paper on the design, characterization of the exposure setup together with experimental results is in preparation. The final measurement campaign is still ongoing.

1.2 Findings

The findings up to now can be summarized as follows:

- the newly designed exposure chamber allows controlled and reproducible experiments in real time of bio macromolecule exposed to electromagnetic fields at specific temperature
- the CD signal of protein grpE exhibits long term stability and highly sensitive dependency on temperature in the physiological range of 20 - 50 °C
- GrpE is a well suited target to assess changes induced by small temperature variations and exhibits high reversibility and long term stability in experiments.

1.3 Problems

- Project was delayed due to the schedule of the workshop and due to unforeseen absences of key personnel
- Due to financial restrictions only a limited range of frequencies and amplitude ranges could be covered

- based on the current number of conducted measurements no conclusive statements on the project hypothesis can be drawn. Additional measurements will be conducted within the next months.

Expansions:

- Design of special cuvettes allowing for direct temperature control of the sample and therefore achieving higher ratios of induced temperature-field strength
- Design of an exposure chamber for ELF-exposure of protein solutions in order to cover the ELF range
- Further experiments using GrpE and other proteins
- Further experiments using GrpE in buffer solutions increasing the vulnerability of the protein and therefore increase the probability of an interaction (?)
- Further experiments using DNA

2. Annex

2.1 Publications

2 Conference publications:

Christian Beyer, Ilian Jelesarov and Jürg Fröhlich, "Real-time observation of potential conformational changes of proteins during EMF exposure" - *IEEE EMBC conference Vancouver, Canada, 2008.*

Christian Beyer, Ilian Jelesarov and Jürg Fröhlich, "Thermosensor protein grpe of heat shock protein hsp70 system as target for electromagnetic fields" - *joined BIOEM and BEMS conference Davos, Switzerland, 2009.*

1 Technical report:

Christian Beyer, Ilian Jelesarov and Jürg Fröhlich. "Thermosensor grpE of heat shock protein hsp70 system as target for high-frequency electromagnetic fields - status report" - Technical report, FSM Switzerland, 2007.

2.2 Documents

Attached the short final report summarising the state of research

Date and Signature