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Special Issue on

Delivery of Ultrashort Electric Pulses to Biological Targets and Resulting Effects

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The biological effects of ultrashort intense electric pulses from nanoseconds to picoseconds have recently gained strong attention in the research community because they differ from the electroporation-based effects activated by millisecond or microsecond pulses. The highlight of research into ultrashort pulse effects is the possibility of intracellular manipulation. This holds for electric pulses with durations shorter than the cell membrane charging time constant, which for mammalian cells is in the hundreds of nanoseconds range, although cell membrane interactions, such as membrane permeabilization, cannot be ignored. The mechanisms of biological responses are still not well understood, yet the applications using ultrashort electric pulses have grown in areas including tissue ablation, stimulation (antitumor immune response, calcium entry, internal calcium mobilization, neurosecretion), wound healing, and treatment of cardiac arrhythmias.

The fundamental questions of ultrafast electric pulse generation and delivery to cultured cells or tissues, the associated dosimetry, and the resulting side effects (such as heating or electrochemical reactions) still require clarification with significant input from engineers and physicists. Applying ultrashort pulses makes the stray inductive and capacitive parameters inherent to the generator and delivery system more pronounced and may seriously affect the characteristics of the actual pulses to which a target is exposed. The pulse distortion due to impedance mismatch and the dispersion by the biological specimen, for example, can also affect the pulse shape, motivating a rigorous analysis of the full system.

Furthermore, nanosecond and picosecond pulse durations make it possible to deliver the pulses with antennas rather than electrodes. Conventional antennas, such as dipole antennas with loadings, multi-resonance antennas, and reflector antennas, can radiate the pulses to biological targets, but the radiation pattern and efficiency must be carefully examined since the target is in the near field region. Efficiently coupling electromagnetic energy to tissues requires more research on the interface from antenna to tissue.

Finally, the biological processes caused by ultrashort pulses, such as membrane charging, effect of macromolecules, and transition from resistive phase to dielectric phase, need to be better understood. How pulsed electric fields of such short duration and high electric field amplitude initiate biological processes is of great interest to the bioelectrics community.

This special issue aims to elucidate the generation, delivery, and resulting biological effects of these nanosecond/picosecond pulses.

Potential topics include but are not limited to the following:

- Picosecond or nanosecond high voltage pulse generators
- Analysis of pulse propagation from a generator to a biological load
- Delivery of electric pulses to a biological target using antennas
- Effect of ultrashort pulses on biological targets
- Molecular level analysis and modeling of electric fields with biological cells

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