# Ultrasound pressure in sonoporation experimental system: modeling and measurements

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## SUMMARY

Sonoporation is a phenomenon where ultrasound increases cell membrane permeability [1]. As the result, molecules that are otherwise deprived of transport mechanisms can be transported across the cell membrane.

We developed an experimental system based on progressive ultrasound wave in a water bath. It consists of a transducer operating at 29.6 kHz submerged in a water bath. We also built a finite element model of the system in order to calculate ultrasound parameters that are inaccessible by conventional hydrophone measurement due to equipment limitations. The experimental system will enable exposure of cells to pre-measured and pre-calculated ultrasound conditions.

## METHODS

A water bath (68 cm x 38 cm x 34 cm) was filled with distilled water up to a height of 24 cm [2]. Ultrasound was generated using a prototype center bolt piezoelectric ultrasound transducer with an operating frequency of 29.6 kHz (Iskra Medical, Slovenia). The transducer was submerged in a water bath at a depth of 12 cm. Ultrasound pressure was measured with a piezoelectric hydrophone (8103 hydrophone, Brüel & Kjær, Denmark) that was located on the central axis of the transducer [3]. The acoustic pressure generated in water by a composite ultrasound transducer was modeled using finite element method (FEM) in Comsol 3.5 (Comsol Group, USA), by coupling structural mechanic, piezoelectric and pressure acoustic equations. The transducer's geometric parameters were measured on a prototype ultrasound transducer (Iskra Medical, Slovenia). The RMS pressure distribution in the model was calculated in 2D axial symmetry mode [4, 5]. In order to compare it to measured values; we used results from the center of the axial symmetry (Fig. 1).

## RESULTS

The maximum RMS pressure value calculated using the FEM model was at the transducer's boundary and had a value of 127 kPa. Experimental data at this distance was not accessible due to spatial restrictions of our experimental setup. The first measurement was therefore done 1.5 cm from the transducer with a measured value of 111±10.6 kPa and calculated value of 91 kPa. Both, measurements and calculated values, showed an expected exponentially decaying RMS pressure values as a function of the distance on the central axsis of the transducer.

The results from the FEM model gave a good description of the system's behavior, although the calculated values were slightly smaller than those obtained experimentally.

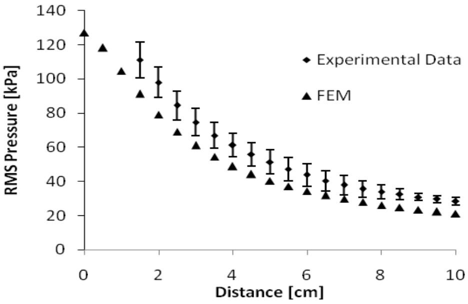

Fig. 1. *The root mean square (RMS) value of ultrasound pressure at axial center of the transducer, as a function of distance between the transducer and hydrophone; the data was acquired using hydrophone measurements (diamonds) and FEM model (triangles); distance on transducer's central axis was varied from 1.5 to 10 cm in steps of 0.5 cm*

## DISCUSSION

Achieving the good agreement between the hydrophone measurements and FEM model results we can conduct experiments at known ultrasound pressure anywhere in the experimental bath. In such a system, it is possible to expose biological materials to incident ultrasound under known pressure.

## LITERATURE

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