CaviPlasma: The properties of energy-efficient plasma source for the treatment of liquids on the scale of cubic metres per hour

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In recent years, the study of plasma treatment of liquids, particularly water, gain high attention in the field of plasma physics [1-3]. The main liquid products of such treatment are reactive oxidizing species with, or without the nitrogen (ROS, RONS) [4-6]. Discharge-liquid technologies have found diverse applications, spanning cross-disciplinary fields such as pollution cleaning, bio-medical research, or food industry [7-9]. Despite two decades of dedicated research, a significant challenge persists: the development of an effective method for treating large volumes of liquid. In our contribution, we will present an innovative solution named CaviPlasma (depicted in Fig. 1). This approach leverages a synergistic combination of hydrodynamic cavitation and plasma generation within the cavitation vapor cloud. Our method holds promise for overcoming the technological barriers associated with large-scale liquid treatment [10-12].

The image of electric discharge generated in fast flowing liquid (water) using the latest generation of CaviPlasma technology is given in Fig. 1. The CaviPlasma technology consists of hydrodynamic circuit producing hydrodynamic cavitation cloud using Venturi nozzle. In this subatmospheric pressure environment (approx. 3 kPa at room temperature) the electric discharge is generated using a pair of metal electrodes placed in the throat of Venturi nozzle and a downstream electrode positioned at the collapsing end of hydrodynamic cavitation cloud. This configuration enables high-throughput at reduced hydrodynamic losses keeping a high plasma-chemical efficiency. The position and polarity of the nozzle electrode is indicated in green in Fig. 1.

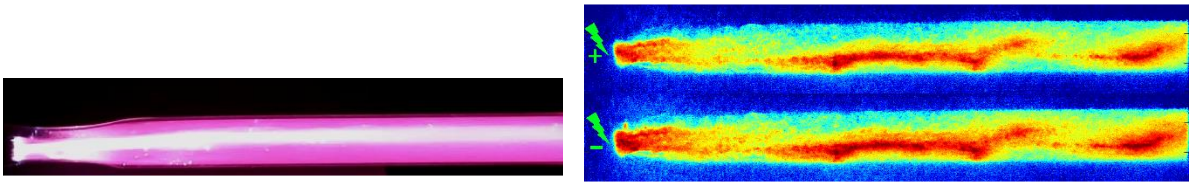

Fig. 1: CaviPlasma technology: image of discharge in reaction tube: P = 1.5 kW, f = 32 kHz, Q = 23 l/min (1.4 m^3/h), tube length 12 cm. (Left) Visual appearance, (right) phase-resolved imaging (half-periods).

In Fig. 2 the current-voltage waveforms for discharge generated in deionized (DI) water using titanium electrodes are given together with the avalanche photodiode signal following the spectrally unresolved emission of the discharge. The photodetector was positioned above the nozzle electrode. From the evolution of current and voltage we suppose that the discharge starts as a sub-μs transient spark discharge and then develops as a glow-like discharge for approx. 12 μs, repeating at the polarity reversal.

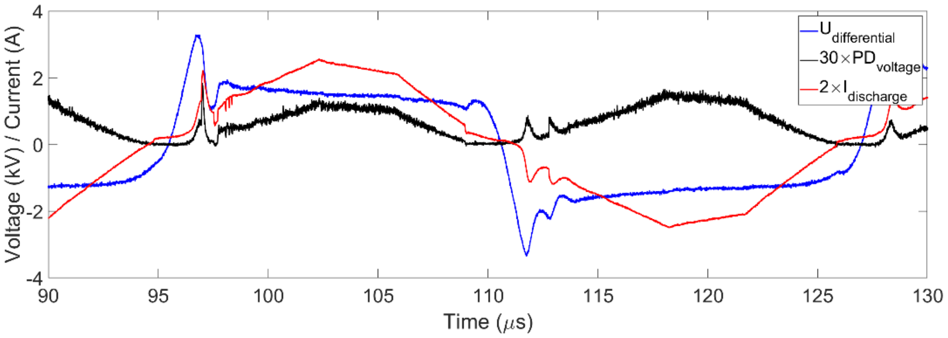

Fig. 2: CaviPlasma technology: (red) discharge current, (blue) imposed voltage, and (black) photodiode signal above nozzle electrode. Given for P = 1.5 kW, f = 32 kHz, Q = 23 l/min (1.4 m^3/h), tube length 12 cm.

In Fig. 3 the typical treatment efficiency and typical treatment conditions of lab-scale CaviPlasma unit are given for DI water, together with the experimental setup used for discharge diagnostics.

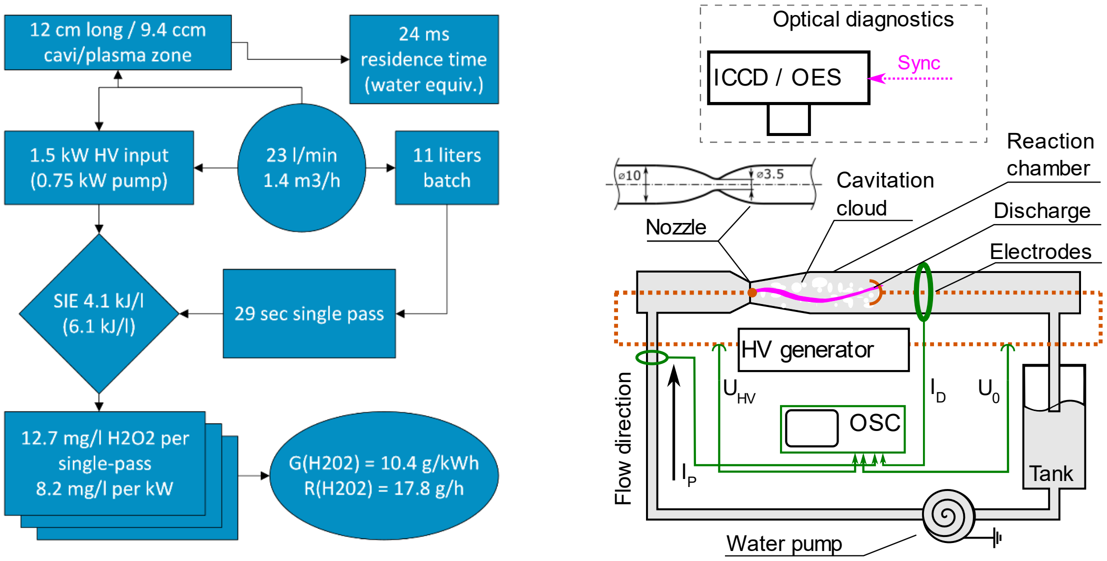

Fig. 3: CaviPlasma technology: (left) treatment efficiency graph, (right) diagnostics experimental setup.

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