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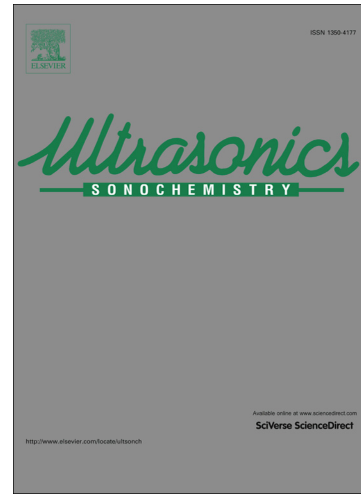

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Observation of chemiluminescence induced by hydrodynamic cavitation in microchannels.

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We have performed hydrodynamic cavitation experiments with an aqueous luminol solution as the working fluid. Light emission, together with the high frequency noise which characterizes cavitation, was emitted by the two-phase flow, whereas no light emission from luminol was recorded in the single phase liquid flow. Light emission occurs downstream transparent microdiaphragms. The maximum level of the recorded signal was around 180 photons per second with flow rates of 380 µl/s, that corresponds to a real order of magnitude of the chemiluminescence of 75000 photons per second. The yield of emitted photons increases linearly with the pressure drop, which is proportional to the square of the total flow rate. Chemiluminescence of luminol is a direct and a quantitative demonstration of the presence of OH hydroxyl radicals created by hydrodynamic cavitation. The presented method could be a key to optimize channel geometry for processes where radical production is essential.

Keywords : hydrodynamic cavitation, chemiluminescence, luminol, radical production, microfluidics.

1. Introduction.

Cavitation is considered as an interesting process due to the physical or chemical transformations that can be induced by the collapse of small vapor bubbles in a liquid. It is an efficient way to focus the energy gathered during the growth phase and released onto a small volume during the collapse phase. Typically, these bubbles can be induced by a periodic acoustic excitation (20kHz - 1MHz) or by a constriction in a flow of liquid, where due to Bernoulli's principle, a pressure drop would arise in the accelerating flow. The former is called ultrasonic or acoustic cavitation (UC) and the latter hydrodynamic cavitation (HC). For both cavitation types, the violent bubble collapse is responsible for the chemical transformation, caused either by the high temperatures and pressures at peak collapse (hot spot) or by mass transfer at the vicinity of the bubbles. The hot spot parameters depend on several factors, such as the bulk temperature of the liquid (which monitors the vapor pressure) and the nature of the dissolved gases in the liquid [1, 2]. Inside the bubble, the vapor phase of the fluid attenuates the efficacy of the collapse, but the noble gases present inside the bubble lead to a higher temperature at the end of the adiabatic collapse. With aqueous solution as the working fluid, water vapor molecules that do not condensate may be broken and produce the reactive radicals, primarily the OH hydroxyl radical [3]. However, a quantitative analysis of the chemistry associated with the cavitation of multibubble clouds is rather difficult, because several unknown parameters such as the number of active bubbles, their average size, the real pressure exerted onto each of them, are involved.

The frequency, the intensity of the pressure field exerted upon the liquid under test and the duration of the exposure to cavitation, are key parameters for the evaluation of the sonochemical efficiency. These parameters are easily adjustable in ultrasonic cavitation devices operating at a laboratory scale. Low frequency cycles generate large bubbles and violent collapses that are apt to produce radicals. High frequency cycles generate more events with smaller bubbles which