Cavitating flow in microchannels : thermal effects and chemiluminescence.

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Cavitating flows are usually found in many industrial applications. Cavitation corresponds to a phase change induced by pressure decrease below the saturated vapour pressure. This can be performed by acoustic waves, which is ultrasonic cavitation (USC), or by generating high speed flows, which is hydrodynamic cavitation (HC). Despite the large number of researches on that topic, many open questions are still unanswered. Among those questions, the role of the thermal effects coupled to the evaporation and to the condensation of bubbles clouds is very important for choosing model closure in numerical tools used for industrial design. A second question of interest is about the chemical reactions possibly induced by cavitating flows. During the collapse, the temperature inside the bubbles is suspected to reach a very important value ($T > 5000$ K). Sonoluminescence, which is light emission at the end of bubble collapse, has been observed both in USC as well as in HC experiments for a flow above an hydrofoil at the trailing edge [2]. That light emission, which is attributed to ionization of rare gas inside the bubble, demonstrates the violence of bubblecollapse which engenders sonochemistry because H_2O molecules may be broken into the reactive OH and H radicals. Even if it has been shown that some molecules can be broken in HC flows [1], there is up to now no consensus on the real efficicency of HC versus USC for wastewater treatments, nor any direct evidence of the formation of OH radicals in HC.

Hydrodynamic cavitation ‘on a chip’, that means inside microchannels equipped with a local constriction, appears to be an unrivaled method for the study of thermal effects and sonochemistry in HC. Experiments unavailable at macroscale become now possible, with devices working with low flow rates, able to handle a low amount of liquid and which can resist to an operating pressure of 20 bar. We have performed experiments through microdiaphragms, that has enhanced for the first time the thermal effects in water cavitating flows. For that purpose, the samples were mounted on a confocal microscope and thermosensitive nanoprobes functionalized with fluorescein were seeded into water. Such an approach has allowed us to draw a 2D mapping of the temperature in the liquid phase and to identify evaporation and condensation areas [3, 4]. Latest experiments have been performed to evaluate the possible production of OH radicals in HC. We have used an aqueous solution of luminol as the working fluid flowing through a microchannel. For the first time, chemiluminescence signal correlated to two-phase cavitating flows was quantitatively recorded [5]. The production of OH radicals is found to correspond to the end of the cavitating pocket, where vapour bubbles are expected to collapse and condense. Other innovative microfluidic experiments about laminar hydrodynamic cavitation will be also presented.

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