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Post-doc Position

Chemiluminescence of luminol subjected to hydrodynamic cavitation 'on a chip': a fundamental step towards wastewater treatment by green technologies

Project summary

Cavitation, the growth and sudden collapse of vapor bubbles, is considered for a long time as a promising tool able to contribute to the development of clean technologies. The violent bubbles collapse is responsible for chemical transformations caused by the high temperatures and pressures reached at the end of the collapse and by mass transfer at the vicinity of the bubbles. The hydroxyl radicals °OH, which are created from the break of H_2O vapor molecules present in the collapsing bubbles, are able to oxidize pollutants present in the aqueous solution. Bubbles issued from ultrasonic acoustic waves in a vessel (UC) are submitted to a pressure field, a frequency of excitation and an acoustic power that are firmly defined, and molecules present in the area of acoustic cavitation are permanently exposed to the process. Hydrodynamic cavitation (HC), which is generated by the passage of a liquid through a physical constriction, allows the processing of larger volumes of fluid, that could be useful for industrial applications such as wastewater treatments. But the operational time during which a molecule is submitted to the effects of a collapsing bubble is then very short and the yield of °OH radicals is believed to be several orders of magnitude lesser than in ultrasonic reactors. There is a need to improve fundamental knowledge of the mechanisms arising in vaporous clouds in HC. We propose a new experimental approach that consists in performing hydrodynamic cavitation of luminol aqueous solution inside microchannels. Chemiluminescence of luminol, which demonstrates the presence of °OH radicals, has been already characterized in ultrasonic reactors, but only one recent reference considers chemiluminescence of luminol in macroscopic HC reactors [1]. Recently, our team has observed the chemiluminescence of luminol in hydrodynamic reactors thanks to a 'lab on a chip' with HC inside [2]. A quantitative determination of the yield of the °OH radicals becomes now possible and the project aims to perform a complete set of experiments in order to get fundamental knowledge about the mechanisms at the origin of °OH production in hydrocavitating flows, and to compare them to those at the origin of sonochemistry. The results of that study will have a crucial importance for some further applications of HC to wastewater treatment.

The project brings two teams from LEGI (*Industrial & Geophysical Flow Laboratory*) and LRP (*Rheology & Process Laboratory*) together. For the past seven years, the team from LEGI has developed the concept of HC 'on a chip', that is hydrodynamic cavitation arising in microflows, with flow rates below 1 liter / hour through micromachined devices. The LRP team has a recognized expertise in sonochemistry [3]. The present study focuses on hydrodynamic cavitation of luminol as the working fluid, and the small size of the devices under test makes possible fine photons counting in a light – proof housing. The Post Doctoral applicant will have to set up the light-proof housing of the microfluidic devices and the photons detection system. He / she will perform hydrodynamic experiments with luminol as the working fluid, onto a set of different microchannels, and will proceed to the analysis of the chemiluminescence. The post-doctorant fellow will also have to implement piezotransducers onto the microdevices, to study the chemiluminescence induced by acoustic waves onto the microdevices filled with the luminol solution and to compare the light emission with that from HC 'on a chip'. A limited number of test campaigns should take place in Lyon University with scientific partners from the Light & Matter Institute.

Location and practical aspects

The successful applicant will be hosted by the laboratory LEGI (*Industrial & Geophysical Flow Laboratory*) in collaboration with the laboratory LRP (*Rheology & Process Laboratory*). Both laboratories are located on the campus of the Grenoble Alpes University, France. He/she will work under the supervision of Pr F. AYELA (*LEGI*) in collaboration with Pr N. GONDREXON (*LRP*). The applicant will also take advantage of the micro- nanofabrication facilities present in Grenoble (Nanofab, C.N.R.S.)

The gross salary will be 2518 euros/months, equivalent to a net salary of 2037 euros/month.

Qualifications of the applicant

We are looking for a highly motivated PhD with a strong background in experimental physico-chemistry and/or fluids mechanics and/or acoustics. A former experience in experimental cavitation (hydrodynamic or acoustic) should be a plus.

The preferred starting date is between 1st septembre 2018 and 1st november 2018 for a one year duration.

Applications

Interested candidates should send their CV and cover letter to Pr F. AYELA, LEGI :

frederic.ayela@legi.cnrs.fr

Deadline for the application: 15th july 2018

References :

[1] : M. SCHLENDER, K. MINKE, H.P. SCHUCHMANN, Sono-chemiluminescence (SCL) in a high-pressure double stage homogenization processes, Chem. Eng. Sci. 142 (2016) 1-11.

[2] : D. PODBEVSEK, D. COLOMBET, G. LEDOUX, F. AYELA : *Observation of chemiluminescence induced by hydrodynamic cavitation in microchannels,* Ultrasonics – Sonochemistry **43**, (2018) 175-183.

[3] : V. RENAUDIN, N. GONDREXON, P. BOLDO, C. PETRIER, A. BERNIS, Y. GONTHIER; *Method for determining the chemically active zones in a high frequency ultrasonic reactor*, Ultrasonics Sonochemistry, **1**(2), (1994) S81-S85.

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