VISUALIZATION OF OXYGEN CONCENTRATION FIELDS IN THE WAKE OF BUBBLES BY PLANAR LASER INDUCED FLUORESCENCE

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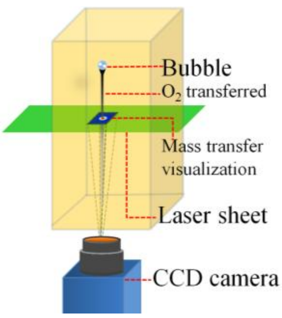
KEYWORDS:

Main subjects: mass transfer, bubble
Fluid: air, water
Visualization method(s): planar laser induced fluorescence (PLIF)

ABSTRACT: The visualization of mass transfer in gas/liquid system is a powerful tool for a first insight in this complex and still under investigation phenomenon. The purpose of this study is to use Planar Laser Induced Fluorescence to first observe and then to quantify the mass transfer of air bubbles in different liquid media which is of prime interest in numerous fields, especially for wastewater treatments. The visualization of this transfer is based on the ability of oxygen, which is transferring, to inhibit the fluorescence of some specific dies added to the liquid phase and excited by a laser light. In the present work, the fluorescent dye used is a Ruthenium complex ($C_{72}H_{48}N_8O_6Ru$, Nanomeps), especially sensitive to the presence of oxygen. Based on previous works, 25 mg/L of ruthenium complex are added to liquid phase with 20% w/w of ethanol to dissolve the dye in aqueous solutions. The light excitation is performed by a Nd: Yag laser (Quantel, λ = 532 nm, 10 Hz, 200 × 2 mJ).

To achieve a local measurement of mass transfer in the wake of air bubbles, a specific set up is proposed. Air bubbles are injected, through a glass capillary, at the bottom of a transparent square cross section column (10×10×30 cm^3). Calibrated bubbles diameters range from 1 to about 3 mm. A laser sheet is generated at 8 Hz and orthogonally to the bubble ascension. The corresponding fluorescence intensity, in the wake of the bubble (Fig.1), is recorded by a Charge Coupled Device Camera (Imager Intense, LaVision, Germany, 12 bits, 1040×1376 $pixels^2$). A 105 mm objective (Micro-Nikkor 105 mm f/8, Nikon) and three teleconverters were added to the digital camera to obtain a focused area ≈ 3×4 mm^2. Since the Ruthenium complex emits around 670 nm, a 570 nm high-pass filter was also placed on the camera to register its fluorescence and to block the laser light. A second CCD Camera is placed orthogonally to the first one and above the laser sheet to record the velocity and the shape of the bubble (image area ≈ 91×120 mm^2). The laser and the two CCD cameras are synchronized by a Programmable Trigger Unit (LaVision).

After image processing and the application of the Stern-Volmer calibration curve, oxygen concentration fields in the wake of the bubble are determined for different distances to the bubble. A global representation of the mass transfer in the bubble wake is performed. This procedure was applied for different bubble sizes and liquid media to be closer from configurations present in wastewater treatment. It has been observed that the "shape" of the mass transfer spot could strongly differ depending on the one of bubbles (Fig.1). From pictures as those presented in Fig.1, the characteristics of mass transfer (mass transfer and diffusion coefficients) of these different oxygen spots are determined with a high accuracy. These measured characteristics are in accordance with literature which seems to confirm the relevance of the presented technique.



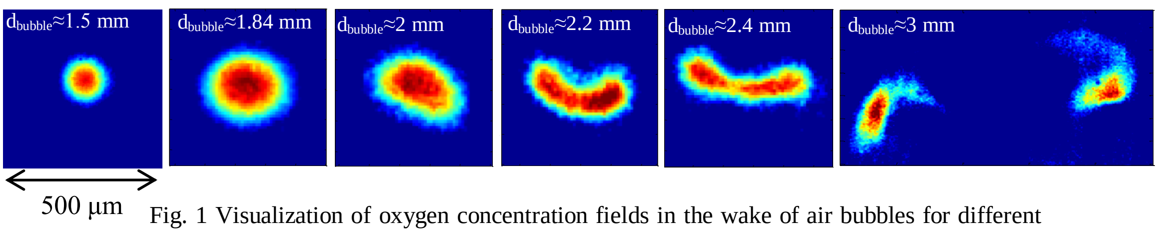


Fig. 1 Visualization of oxygen concentration fields in the wake of air bubbles for different configurations of bubble: from spherical (left) to ellipsoidal bubbles (right). O_2 concentration varies from about 2 mg/L (red) to about 0 (dark blue).