Experimental study of liquid-gas transfers in a stirred tank for biohydrogen production

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Abstract

Besides its important use in the petroleum and chemical industries, hydrogen (H_2) is currently considered as an ideal energetic carrier due to its high energy content and environment-friendly conversion. H_2 generation by microorganisms turns out to be a sustainable and cost-effective production technology. Among the various biochemical mechanisms, dark fermentation appears to be most favorable: anaerobic bacteria grow on various carbohydrate-rich substrates, such as organic wastes, without the need of light energy. Even if this technique has been studied for several years, it is not mature from an industrial point of view. The dissolved H_2 concentration is one of the major key factors mentioned in the literature [1-3]. Due to liquid-to-gas mass transfer limitations, the liquid phase can be supersaturated in H_2 which then inhibits its own production. Transfer rate in a bioprocess strongly depends on the nature of the gas, the physicochemical properties of the broth, the operating and agitation conditions. A better understanding of the hydrodynamic phenomena is thus a necessary step to improve the performance of a bioH_2 production reactor.

In order to characterize hydrogen liquid-to-gas transfer, two optical techniques are going to be used: the Particle Image Velocimetry (PIV) and the Planar Laser-Induced Fluorescence (PLIF). They respectively allow the determination of the spatial distribution of hydrodynamic and mixing quantities and of the spatiotemporal evolution of dissolved H_2 concentration fields. Very detailed analysis of liquid flow in the bioH_2 reactor based on PIV measurements will only be performed in a few preselected setups. Indeed, the most promising configurations (number and type of impellers, position …) and agitation conditions (rotating speed) will first be determined by studying their respective influence on global parameters such as mixing time, dissipated power and volumetric mass transfer coefficient. On the other hand, PLIF doesn't give direct access to dissolved H_2 concentration fields because no tracer currently exists. This method will thus be used to measure dissolved oxygen (O_2) concentration fields as a function of operating conditions and these results will be used to estimate dissolved H_2 concentration fields in similar conditions. The analogy between O_2 and H_2 transfer kinetics will be established and validated on the basis of dissolved gas concentration measurements made with specific but local probes.

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