LABO – Institut Pascal Axe GePEB

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Title of PhD subject: Intensification of biological methanation process: from hydrogen solubility limitation to inhibition by excess of dissolved hydrogen

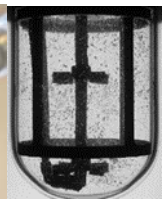
Summary :

With an annual production estimated at 500 millions of tons of methane, methanogen archaea are a key actor of global carbon cycle. The formation of biological methane from hydrogen (H2) and carbon dioxide (CO2), id est biomethanation, is not only an important process in terms of quantity but is also one of the oldest processes [1]. From an industrial point of view, this reaction has a double interest: (i) the production of an stocrable energy vector (CH4) from an intermittent energy; (ii) a contribution to decarbonation. Industrialisation of biomethanation reactors is nevertheless limited by the rate of gaz/liquid hydrogen transfer [2, 3]. A classical solution to solve this problem is the increase the stirring but this has an antagonist effect on biological processes with archaea that are sensitive to mechanical stress inducing a reduction of productivity. A compromise need to be found; furthermore, energy cost due to the stirring can be an additional economical limitation of the process.

A patented process involving gas/liquid system in a bubble column has recently been developed in the GePEB axis [4]. It has been shown that biomethanation process was probably related to an enhancement of H2 transfer rate or an increase of gas/liquid interfacial area due to biosurfactants in situ generation that is unavoidable for a long period of process time. Theoretically, a fast biological reaction could induce and enhancement of gas/liquid mass transfer [5], but this enhancement has never been clearly demonstrated according to the literature.

In the context of this PhD, original experiments with microbial consortia full of methanogen archaea will be carried out to measure the volumetric transfer rate (kLa). Two different devices will be used : (i) a thermostatic and pressurized cell and (ii) a bubble column, both equipped with a dissolved hydrogen sensor in order to conclude on the hypothesis of enhancement of gas/liquid transfer rate during bio-methanation process. A progressive raise of pressure will be tested in order to be freed from H2 transfer limitations but also to determine the maximum pressure where inhibition can appear on biomethanation process that can happen when to much H2 is dissolved in the liquid phase (7). Concerning gas/liquid interfacial area, trials on specific sparger and the presence of surfactants will be carried out. This surfactants would be those produced in biomethanation experiments because cells generate and release them in the culture medium affecting the transfer. The presence of these surfactants reduce indeed surface tension of the culture media inducing the formation of smaller bubbles and as consequence increasing interfacial area. This increased interfacial area would then be responsible for the increase of volumetric transfer rate kLa. These surfactants nonetheless can either have a negative effect [11] opening a discussion in the scientific community [12]. The mechanisms explaining the role and influence of surfactant on mass transfer coefficient and specific interfacial are would then be also studied in the context of this PhD.





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