1. Development of microfluidic and trickle-bed reactor technologies to investigate, model and reduce the crucial bottleneck of liquid-gas H\textsubscript{2} transfer in biohydrogen production by \textit{Clostridium bacteria}

Summary: Hydrogen is a promising energy vector for the future since CO\textsubscript{2} is not released during its combustion. Whereas current H\textsubscript{2} production relies mainly (i.e. 95%) on fossil fuels, promising advancements are carried out for the last decades to produce biohydrogen from renewable sources such as biomass through a process called “dark fermentation”. However, one of the most crucial issues still to address deals with liquid-to-gas transfer of the H\textsubscript{2} produced in liquid culture medium since 5 to 10-fold supersaturation phenomena are frequently observed in bioreactors compared to the equilibrium conditions. As a consequence, the production yields are quite low, particularly in large-scale bioreactors.

The objectives of the project are to use microfluidic techniques (collaboration with TIPs – B Scheid) and trickle-bed bioreactors in order to better understand the microscopic phenomena of L/G H\textsubscript{2} transfer and to design and optimize new original bioreactors.

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2. Development of mathematical models to investigate and optimize biohydrogen production by \textit{Clostridium bacteria}

Summary: On the same thematic of subject 1, the objectives of the project are to develop accurate mathematical models and model-based optimization of the bioprocess at different scales and working conditions (collaboration with 3BIO-BioControl – Ph Bogaert). Up to date only few models were developed for biohydrogen production since the majority of the papers in this field dealt with mixed cultures of microorganisms and relatively raw residual substrates. By contrast there is a large amount of experimental results with \textit{Clostridium} pure strains in different working conditions. These will be exploited for building dynamic mathematical models. Among the different bioreactor systems that were investigated, a continuous trickle-bed system and a biodisc-like bioreactor were already tested successfully for biohydrogen production.

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3. Development of an original bioreactor system to valorize the starch-rich wastewater from potato-processing industry

Summary: Agro-food industries generate large quantities of by-products and effluents rich in organic molecules that are not or little valorized at their highest level of intrinsic value. Currently, the outcome is the aerobic treatment plant (with high energy needs) or the anaerobic digestion plant with some profits from methane-based bioenergies. Focusing on the potato-processing industry, the project aims to study the valorization of some flows particularly rich in starch and proteins through fermentation technologies. An original bioreactor system will be developed in order to promote growth of specifically added microorganisms and prevent contamination directly at the effluent output from the industrial process. The costs associated with the processes to be implemented will be estimated and compared to prices of competing end-products currently on the market. They will also be compared with current treatment costs of these waste streams.

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4. Development of fermentation processes for production of cell biomass or metabolites (enzymes, biopesticides, acids or alcohols)

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5. Development of waste-to-energy processes from residual organic material (household, agro-industrial, agricultural origin)

Summary: Investigation of methane potential and biogas production kinetic from different organic molecules (BMP tests and in pilot-biodigesters). Monitoring of physico-chemical parameters and produced metabolites (carbohydrates, acids, alcohols, H₂, CO₂, ...). Industrial-scale dimensioning.

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