Micro-organism motility and transport phenomena in suspensions of particles with molecular driving force for production of biofuels- a physico-biological study

Context

The current global energy crisis combined with the strong increase in energy consumption present the world with the serious problem of providing and securing the resources needed to produce energy and meet the increasing demand associated with economic growth. Thus, the demand for energy production relying on renewable and sustainable sources has become global.

The third generation of bio-fuels produced from non-feed stocks such as microalgae and cyanobacteria, offers increasing opportunities [1,2]. Microalgae and cyanobacteria are microscopic photosynthetic organisms; found in aqueous environments, they thus have efficient access to water, CO_2 and other nutrients, and are generally efficient in converting solar energy into biomass.

In this PhD program we are interested in the fundamental aspects of bio-hydrodynamical behavior of the cyanobacteria, mainly characterized by their motility in a fluid flow. This knowledge is crucial for the understanding and modeling of the transport phenomena in photo-bioreactors dedicated to biofuel production from micro-organisms. This interdisciplinary subject benefits from the collaboration of a group of physicists, biologists and engineers working on the *energy of future*.

Thesis project

The cyanobacterium is a prokaryote freshwater unicellular bacterium. Due to its photosynthetic properties and its ability to grow in areas hostile to other cultures, it may present a new and sustainable way to produce biofuel [3-5]. Indeed, cyanobacteria can be *genetically engineered* in order to reach photosynthetic efficiencies of 3-9%. This value must be compared with the typical photosynthetic efficiency of terrestrial organisms, which is around 0.25-3%.The water required to produce a kilogram of dry protein is also reported to be less for the most extensively cultivated cyanobacteria *Arthrospira platensis (Spirulina)* than for other typical species of cultures.

In addition, such bacteria also display a phototactic behavior enabling them to head toward light. This can be detrimental to bio-reactor efficiency, since the migration of bacteria near the surface decreases the intensity of transmitted light and hinders photosynthesis. In this PhD program we focus on the behavior of cyanobacteria at a fundamental level and investigate its movement (motility) in the core of a suspension of a population of micro-organisms as well as in micro-fluidic photo-bioreactors.

It has been observed that bacterial motility can be divided into two parts: high-speed “run” phases and low-speed “tumble” phases. This intermittent motility may be related to the optimal strategy for finding targets in a homogeneous environment. With this kind of motility, bacteria accurately explore a reduced area during low-speed phases and change their search area by high-speed motility. One of the objectives of this PhD work is to monitor physically this movement, understand its underlying mechanisms and model the motility of the micro-organism. Parametric studies will also be carried out for understanding of the effects of different environmental (nutritive, light radiation, chemical composition etc.) parameters on this motility. In-vitro and in-situ experiments will be performed in micro-fluidic and prototype novel photo-bioreactors. Based on these findings, the final aim of this work is to propose novel designs of micro photo-bioreactors and also efficient particle trapping systems applicable to harvesting step of biofuel production. These experiments will benefit from the very modern and up-to date physics and biology laboratory platforms of the université Paris-Diderot.

References

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