Behaviour of Dunaliella Salina in microfluidic contraction devices

V. Infante (a,b), M. Haw (a), M. S. N. Oliveira (b)

[a] Department of Chemical and Process Engineering, University of Strathclyde, Glasgow G1 1XJ, UK; [b] James Weir Fluids Laboratory, Department of Mechanical and Aerospace Engineering, University of Strathclyde, Glasgow G1 1XJ, UK.

e-mail: vincenzo.infante@strath.ac.uk

Abstract

The importance of microorganisms and their fundamental functions in different contexts is well-documented; they constitute a major part of the world's biomass and play a vital biological role in ecosystems. Microorganisms can be found in almost every part of the biosphere and are utilised in a wide range of applications that encompass food and beverage preparation, genetic engineering and renewable energy. [1, 2]

Microswimmers are a particular variety of microorganisms, which can swim and propel themselves and that have unique characteristics compared to passive particles (i.e. motility, sensing, feeding and settling rate [3]). Microswimmers include bacteria, spermatozoa, unicellular, colonial algae and protozoans. [1]

This work focuses on the fluid dynamic behaviour of *Dunaliella Salina* (DS) (a type of planktonic halophile green micro-algae especially found in sea salt fields) in microfluidic contraction-expansion geometries for varying flow conditions, in order to exploit its use in engineering applications, (e.g. biodiesel production, waste treatment, bioreactor engineering), and to improve their current efficiency.

In many of these applications DS works as a "transporter" flowing through complex environments with contraction and expansion features that involve micron-sized length-scales (e.g. porous soil, biotissue, complex process flow geometries). The manner in which algae swim and orientate relative to the main flow direction is largely influenced by the fact that DS swims at very low Reynolds numbers where viscosity dominates over inertia – a typical condition achieved at the micro-scale. The efficiency of its swimming is a key factor in enabling transport and controlling the process.

Experimental investigation is currently underway considering different microfluidic abrupt contraction-expansion geometries with different contraction ratios (CR = 2, 4 and 8), including the visualisation of the algae's motion using an inverted microscope, and tracking their motion using software, such as cellSens® and Matlab, in order to understand the algae's behaviour and how their motion is influenced by the surrounding environment and flow conditions. We have been able to distinguish three regimes: the absence of flow where the mean flow velocity is relatively smaller than the algae swimming speed and DS cells swim randomly; the flow of intermediate strength where the flow begins affecting the algae behaviour but they can still partially withstand the flow rate and the flow advection where the flow advection dominates over motility and algae trajectories tend to the fluid streamlines.

With this work, we hope to pave the way toward new viable engineering solutions where the DS's peculiarities may be exploited, such as all the applications involving algal concentration or separation processes (i.e. biofuel production, algal bio-detector, etc.). [2] A concerted motion at

microscopic scale can also be exploited for environmental purposes as some microalgae tend to cluster creating toxic algal blooms that can be limited or prevented. [2]

References:

[1] Pedley T. J., & Kessler J. O. (1992). “Hydrodynamic phenomena in suspensions of swimming microorganisms”. *Annual Review of Fluid Mechanics*,*24*(1), 313-358.

[2] Haw M. & Croze O. (2012). “Physics comes to life”. *Physics World*, *25*(2), 39-43.

[3] Guasto J. S., Rusconi R., & Stocker R. (2012). “Fluid mechanics of planktonic microorganisms”. *Annual Review of Fluid Mechanics*, *44*, 373-400.

Keywords: algae, microfluidics, rheology.