HIGH SHEAR STRESS FROM A RESONANCE PHENOMENON IN WAVE BIOREACTOR REVEALED BY COMPUTATIONAL FLUID DYNAMICS SIMULATION

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Wave bioreactors are getting a wide acceptance for the culture of human cells. These bioreactors are attractive for sensitive cells such as stem cells or immune cells, in suspension, aggregates or adherently growing on microcarriers. The optimization of the mixing, the oxygen transfer rate and the shear stress require a deep understanding of the hydrodynamics taking place in the Wave bioreactor bag.

In the present study, we perform numerical simulations (Ansys-FLUENT) to characterize the flow conditions in a 10L cellbag [1]. The numerical simulations were carried out to investigate the fluid structures for nine different operating conditions of rocking speed and angle. The mixing and the shear stress induced by the liquid motion were studied. We observed that these increased with the cellbag angle from 4˚ to 7˚ but that the highest rocking velocities were not systematically associated with the highest mixing and shear stress. As a matter of fact, the lowest studied rocking speed, 15 rpm, generated the highest fluid velocity, mixing and shear stress compared to the higher speeds of 22 and 30 rpm. It was concluded that a resonance phenomenon was responsible for this behavior.

These observations were theoretically benchmarked against shear stress levels reported in the literature. Although the obtained shear stress levels in a Wave bioreactor were lower compared to stirred tank bioreactor, their magnitude was such that they could have an influence on the cell metabolism or could lead to cell lysis of cells adhering on microcarrier. On another hand, the studied operating parameters of speed and angle generated a shear stress too low to obtain the formation of aggregates or spheroids. Therefore a system generating harsher shear stress than the Wave bioreactor would be more suitable for the formation of cell aggregates.

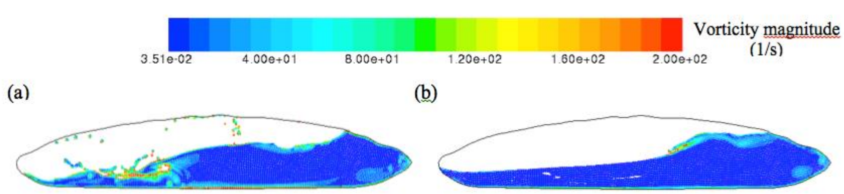

Figure 1. Vorticity magnitude in the liquid phase for angle 7° and speed (a) 15 rpm or (b) 30 rpm by 2D simulation in 5 L volume.

Reference

[1] Zhan, C, Hagrot, E, Brandt, L, Chotteau, V. (2018). Study of hydrodynamics in Wave Bioreactors by Computational Fluid Dynamics reveals a resonance phenomenon. Chemical Engineering Science. 10.1016/j.ces.2018.08.017.