Fall 10-20-2015

Evaluation of sweeping as an alternative to sparging in a rectangular single-use bioreactor

Jean Francois Hamel
MIT

The development of single use bioreactors (SUBs) has led to the exploration of novel reactor geometries such as the rectangular, single-use bioreactor (Nucleo™ Pad Reactor, PALL Corporation). Sparging is currently used as the main method of providing oxygen to cells in both the traditional and rectangular bioreactor. However, cell damage from bubble bursting and foam entrapment makes sparging a poor way of providing oxygen for growing cells that are sensitive to these shear inducing effects, such as stem cells. An alternative aeration method, sweeping, provides O_2 by diffusion through liquid air interface, minimizing shear stress damage to cells arising from bubble rupture and foam formation. Although not suitable for cylindrical systems, sweeping has the potential to be a viable method in the rectangular SUB, due to the 2.5 times larger surface area to volume ratio of the rectangular shape.

The mass transfer coefficient (k_La) was calculated using the dynamic method and characterized with respect to varying agitation and aeration rates in water and cell medium with 0.01% Antifoam C concentration. Nitrogen was used to degas the liquid in the SUB and minimize dissolved oxygen levels. Air was then sparged or swept over the system to provide oxygen, depending on the aeration method under investigation. Dissolved O_2 levels were measured with an optical probe that measured oxygen concentration through the fluorescence quenching of an indicator. The mass transfer coefficient was calculated from the slope of the linear portion of the log mean difference in concentration relative to the starting concentration of dissolved oxygen over time. Sweeping k_La values (ranging from 0.09-0.62 h^{-1} in water and 0.17-0.19 h^{-1} in medium) were found to be an order of magnitude less than sparging k_La values (ranging from 1.48-1.86 h^{-1} in water and 1.11-3.26 h^{-1} in medium). While sweeping on its own is not sufficient to supply enough O_2 to support mammalian cell culture in the PadReactor, a combination of maximizing sweeping and minimizing sparging should be pursued further for increased growth of shear sensitive cells, under low oxygen demand conditions.