POC-12-conradie-C1net-public-summary-application

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Intensification of CO2/ H2 Fermentations using 02 as Final Electron Acceptor

The utilization of CO_2 / H_2 with O_2 as final electron acceptor in fermentation is techno-economically advantageous from a carbon feedstock cost perspective. However, given the flammability of hydrogen in oxygen atmospheres, operational safety considerations require that the headspace in a conventional bioreactor be maintained below the limiting oxygen concentration (LOC). This operational constraint demands that high mass transfer rates for oxygen are attained to satisfy the techno-economics, particularly from a capital investment perspective. In turn, attaining such high mass transfer rates may require an uneconomical energy input per volume of fermentation broth. An alternate bioreactor design, alleviating the oxygen mass transfer constraint associated with a flammable gas mixture, is required.

Most industrial fermentation installations follow a suspended culture cultivation strategy less amenable to radical intensification. Vast quantities of water need to be kept in motion, biomass constituting typically less than 3 [%] (w/w). By example, the production of the commodity amino acid, lysine, is undertaken in stirred tank reactors as a prevailing industry standard ever since the 1960s. However, a typically 20 [kt/annum] lysine facility requires ~900 [m^3] of reactor volume. In contrast, a 400 [kt/annum] petrochemical polymer plant employs a single reactor encompassing ~20 [m^3]. The implications to the efficient use of capital are stark.

This C1net project established a novel exoelectrogenic bioreactor concept using *C. metallidurans* as host, exploiting CO_2 fixation using H_2 as electron donor at the anode and O_2 as final electron acceptor at the cathode. The exoelectrogenic reactor thus introduced an anode as intermediary electron acceptor. The bioreactor concept design (1) obviates the need for flammability considerations, (2) lifts O_2 mass transfer restriction dramatically and (3) offers an intensification strategy underpinned by an immobilised culture. Effective capital utilisation in C1 gas fermentation underscores the value creation from this C1net POC award. The project entailed an innovative blend of microbiology and electrochemistry in achieving a novel reactor design, breaking with familiar design considerations.