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

The utilization of CO2 / H2 with 02 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 [m3 ] of reactor volume. In contrast, a 400 kt/annurn] petrochemical polymer plant employs a single reactor encompassing —20 [m3 ]. The implications to the efficient use of capital are stark. A historian, Barbara Tuchman, described the tendency in human nature to emulate the familiar and avoid breaking with the past as the March of Folly (Figure 1).

The overall project aims to establish whether a novel bioreactor concept separating H2 and 02 may be exploited for CO2 fixation using a chemolithotroPh. The bioreactor concept design (1) obviates the need for flammability considerations, (2) lifts 02 mass transfer restriction dramatically and (3) offers an intensification strategy underpinned by an immobilised culture. Effective capital utilisation in C1 gas fermentation underscores the proposed value creation from a C1net POC award. The project entails an innovative blend of metabolic engineering and bioreactor concept design in achieving this objective, breaking with familiar design considerations. The March of Folly is thereby curtailed.