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Microbubble enhanced gas exchange in a methanotroph gas fermenter

When fluidic oscillator driven, energy efficient microbubbles were invented in 2005, there were only two classes of industrial processes exploiting microbubbles -- bioreactors and flotation separations. We have shown that several processes are enhanced or intensified with microbubbles, including liquid mixing, heat and mass transfer, particle separations, evaporation, condensation, distillation, and interfacial reactive distillation. This proposal aims to test the ability of microbubbles injected from two different gas streams to accelerate C1 fermentation. Primarily the proposal will test the ability for air microbubbles to relax the limitation that gas fermenters are oxygen limited, by analogy to their recent usage to relieve this constraint in yeast fermenters that are oxygen starved. It also builds on the observation that microbubbles have been used in anaerobic digesters to strip methane completely, resulting in higher metabolism and methane production (110% maximum observed increase in production rate over the control). Stripping is the inverse of the dosing requirement for methane gas fermenters. Since methane is practically insoluble in water, the effectiveness of microbubbles must be due to intermittent collisions with microbes and biomass where methane accumulates, rather than removal directly from the aqueous medium. Furthermore, with the very low rise time of <10 micron size microbubbles, the contact time is very long, with microbubbles leaving the liquid medium due to size growth due to methane uptake in AD. For gas fermenters, the analogous reason for microbubbles to leave is the extraction of CO_2. Since gas fermenters are typically strongly aerobic, a mixed dosing strategy of methane microbubbles and air / O_2 microbubbles should take advantage of our observed strong aeration rates in microbial bioreactors. Due to high aeration rates achievable, such as in yeast propagation, where dissolved oxygen levels up to saturation were achieved, there is no need for pure O_2 dosing to gas fermenters. The proposed work programme will develop a novel lab bench gas fermenter where substantial care in control systems must be taken for safe operation, due to the flammability of some ratios of oxygen-methane mixtures in the dispersed gas phase.