Steady state and dynamic performance of a two-phase partitioning bioscrubber for the treatment of benzene gas

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ABSTRACT. Biological treatment of waste gases contaminated with toxic volatile organic compounds has classically been achieved using such popular designs such as biofilters and single-phase bioscrubbers. While these configurations have found their own successes, the shortcomings of their operation have led to improved processing strategies through the design and operation of the two-phase partitioning bioscrubber. A two-phase partitioning bioscrubber is comprised of a cell-containing aqueous phase, as well as an organic phase to sequester high concentrations of toxic substrates. Suitable organic phases must be carefully selected to ensure that they are biocompatible, non-bioavailable, immiscible in the aqueous phase, and non-volatile, while preserving sub-inhibitory conditions in the aqueous phase through favorable equilibrium partitioning. The rate of substrate partitioning mass transfer between the two liquid phases should be sufficiently high such that it is controlled by the demands of the cells. High levels of bioactivity can, therefore, be preserved when treating high loads of toxic substrates through the addition of an appropriate organic phase, as sub-inhibitory aqueous concentrations are ensured while not limiting the cells by mass transfer.

Recent design improvements of the two-phase partitioning bioscrubber have led to higher benzene removal rates, improved oxygen transfer, and increased process stability in the face of feed disturbances. Meanwhile, improved operational strategies have capitalized on the phenomenon of cellular maintenance energy, a critical microbiological parameter, resulting in streamlined steady state operation and reduced expenses. Experimental results demonstrate the remarkable performance of the two-phase partitioning bioscrubber, able to maintain high removal efficiencies and superior elimination capacities whether applied via a constant benzene feed, or through dynamic feed variations including benzene spikes and step changes. The robustness of this process is also demonstrated through rapid recovery after restart from a simulated shutdown. The sustainability of this process and its effortless operation is demonstrated experimentally through a long-term treatment.