The use of solid polymer beads for the capture and biodegradation of toluene in two-phase partitioning bioreactors

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ABSTRACT. Two-Phase Partitioning Bioreactors (TPPBs) have traditionally been characterized by a cell-containing aqueous phase, and an immiscible and biocompatible organic phase that partitions toxic substrates to the cells based on their metabolic demand and on maintaining thermodynamic equilibrium between the two phases. Thus, very high levels of toxic substrates can be added to the organic phase of a TPPB, while maintaining sub-inhibitory concentrations in the aqueous phase. A limitation of TPPBs, which use organic liquid solvents is the possibility that the solvent can be bioavailable (ie, consumed as a substrate by the cells), and this has therefore limited organic-liquid TPPBs to the use of pure strains of microbes. We have recently shown that solid polymer (ie, plastic) beads can be used a replacement for liquid organic solvents, offering similar absorption properties, but with the capability to be used with mixed microbial populations for degrading toxic substrates. Here, the performances of different bioreactor configurations (no solvent, solvent, polymer beads) have been examined by inducing inlet concentration spikes and step changes of the incoming toluene contaminated air stream. These tests allowed direct comparison of the dynamic uptake and release of toluene between using organic liquid solvents and polymer beads as a second phase, as well as allowing us to compare the performance of a single strain of bacterium (Achromobacter xylosoxidans) to degrade toluene against the syntrophic effects of using a mixed consortium. Reactor performance were compared in terms of overall toluene removal efficiency during the course of the spike or step, and the dissolved oxygen in each reactor was also used an indicator of performance in terms of toluene degradation and possible oxygen limitations. In addition, abiotic oxygen experiments were performed in order to validate that the presence of polymer beads in a TPPB helps with the mass transfer of oxygen to the cells, as has already been shown in the case of solvents as a second phase.