435a Biofiltration of Hydrophobic Vocs with Filamentous Fungi: Modeling and Experimentation

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Biofiltration is nowadays one of the leading Air Pollution Control (APC) techniques for low VOCs concentrations. In these systems, the VOCs are oxidized by immobilized microorganisms in a solid support and CO2 and water are the main end- products. Biofiltration has important advantages such as low power requirements, it does not use dangerous substances nor uses extreme conditions for its operation and the polluting agent is destroyed and not only transferred to another phase. On the other hand, these systems have shown to be less efficient to treat hydrophobic compounds which are sparsely soluble in the biofilms, which usually contain high water content to allow metabolic activities. Furthermore, the flat bacterial biofilms offer low surface for the transfer of these contaminants to the biologically active phase. One alternative to improve these limitations is the use of filamentous fungi as the biological agents in biofiltration. These organisms are more resistant to acid and low- humidity conditions and the transfer of the hydrophobic pollutant has been shown to be improved by the increased transfer surface, due to the formation of the aerial mycelium, and the more favorable phase equilibrium with the hydrophobic nature of the fungi. The objective of this work is to describe the degradation of hydrophobic VOCs using filamentous fungi on biofilters. The study system will be hexane, as a model substrate, and the fungus Fusarium sp. The system is mathematically described and the main physical (mass transfer, partition and transport area) and kinetic data (growth and degradation rates, maintenance coefficient, inhibition and affinity) will be obtained by independent experiments for verification. The model proposed in this study describes the increase in the transport area by the growth of the filamentous cylindrical mycelia and its relation with hexane elimination in cuasi-stationary state. The proposed mechanism of mycelial growth includes their elongation and ramification, described by a growth kinetic Monod model with double substrate and nitrogen limitation. The concentration of hexane in the fungal surface is determined by a mass balance with the bulk gas phase through a stationary gas layer around the mycelium and considering the gas- biomass partition coefficient. The transport and reaction of the assimilable nitrogen source is also described through the elongating mycelia. In the experimental work, the effect of the carbon source in the hexane/biomass partition and the hydrophobicity of the fungus was determined using three different carbon sources (glycerol, glucose and hexanol). The effect in the hydrophobicity of the fungus was determined measuring the angle of contact of a drop of water with the surface of the fungus with fungi grown on solid hydrophilic and hydrophobic membranes. The biological parameters and partition coefficients were determined in independent experiments in closed batch systems. The affinity constants for hexane and nitrogen were determined by respirometry and found to be 100 g.m-3 and 500 g.m-3, respectively. The maximum growth rate was obtained by determining the CO2 production at different hexane concentrations in the gas phase, obtaining a value of 0.038 h-1 and an Haldane inhibition constant of 1710 g.m-3. Growth inhibition was observed at gas phase concentrations beyond 5 g.m-3. The maintenance coefficient was determined by direct measurement of hexane consumption by Fusarium sp. resting cells and found to be 1.4x10-4 h-1. The adimensional partition coefficients obtained for the fungus grown in liquid cultures with glycerol, glucose and hexanol were 0.19, 0.24 and 0.05, respectively, which contrast with the water partition coefficient of 42.4. This increase in the partition of the hexane in the biomass can be partially explained by the presence of hydrophobins, highly hydrophobic proteins, on the surface of the fungus. This greater partition of hexane in biomass allows greater elimination capacities. These results show that when growing the fungus in a hydrophobic carbon source, the partition of the hexane in the biomass was sensibly improved. The hydrophobicity results show the same tendency that the partition coefficient. Fungi grown on hydrophobic membranes supported on mineral medium agar with glucose, glycerol, hexanol and hexane showed angle contacts of 75.3°, 103.7°, 112° and 113°, respectively. The same tendency was observed in hydrophilic membranes. Initial results in biofilters inoculated with Fusarium sp. showed maximum capacities of elimination of 210 g.m-3h-1, which contrasts with the results obtained with bacteria which are usually an order of magnitude lower.