BIODEGRADATION OF VOLATILE ORGANIC COMPOUNDS IN TWO-PHASE PARTITIONING BIOREACTORS

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Volatile organic compounds (VOCs) are key atmospheric pollutants due to their ozone depletion potential, global warming potential, toxicity and carcinogenicity. VOCs are emitted in chemical and petrochemical industries, printing and textile facilities, pulp and paper industries, etc. The large number of solvents used in these industries results in off-gas emissions comprised of mixtures of VOCs with very diverse hydrophobicity, toxicity and biodegradability. Despite conventional physical/chemical VOC treatment technologies have been progressively displaced by biological technologies, the performance of biological VOC removal is often challenged by the hydrophobicity of some specific VOCs (such as alkanes and terpenes), which limits pollutant transfer from the gas to the aqueous phase. In addition, biological processes are also challenged by surges in the loading rate of emissions containing moderately-soluble toxic VOCs, leading to the inhibition of the microbial community. Therefore, the development of innovative bioreactors supporting a facilitated VOC transfer to the microorganisms and avoiding microbial inhibition must be pursued.

Two-phase partitioning bioreactors (TPPBs) can enhance the mass transfer of hydrophobic VOCs, while minimizing microbial inhibition due to VOC surges. This technology is based on the addition of a non-aqueous-phase (NAP) with high affinity for the hydrophobic VOCs to the biological process. A high concentration gradient is thus established between the gas and the NAP, increasing the driving force available for mass transfer, which ultimately improves the transfer of hydrophobic VOCs to the aqueous phase. The presence of a NAP in the aqueous medium also provides an increase in the gaseous interfacial area available for transfer (Fig. 1). Thus, the use of TPPBs has resulted in unprecedented biodegradation rates.

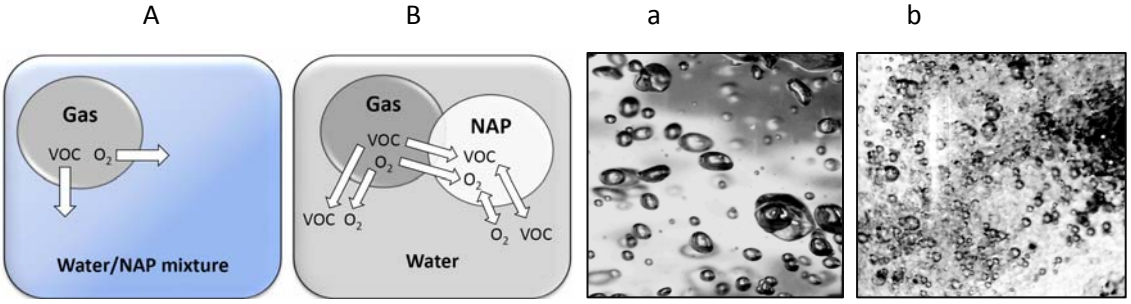

Figure 1. VOC and O_2 mass transfer pathways in conventional systems without NAP (A) and in TPPBs (B). Air bubbles in a stirred tank reactor without NAP (a) and in presence of silicone oil (b). From: Muñoz et al., 2012a; Quijano et al., 2010.

This research project will assess the potential of TPPBs for the biodegradation of hydrophobic VOCs and mixtures of different VOCs under steady state and transient loadings, using different bioreactor configurations such as stirred tank, airlift bioreactors, biofilters and biotrickling filters operated with solid and liquid NAPs. Moreover, research efforts have been done in our laboratory to develop innovative operation modes supporting stable hydrophobic VOC removal, including the confining of the biocatalytic activity exclusively in the liquid NAPs by using hydrophobic microorganisms (Fig. 2). This operational mode, besides allowing for stable VOC removal, can also overcome foaming issues and NAP loses during mineral salt medium renewal.

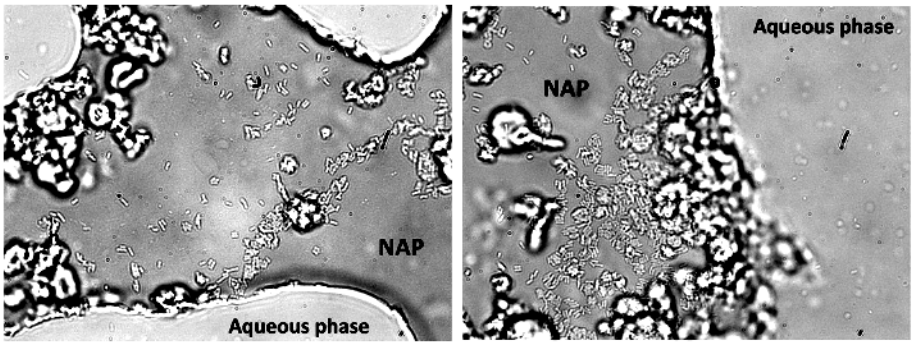

Figure 2. Pictures of silicone oil droplets containing a hydrophobic bacterial consortium (Muñoz et al., 2013).

More information available at:

http://etuva.blogspot.com.es/

Relevant publications

Muñoz R, Gan E, Hernandez M, Quijano G (2013) Hexane biodegradation in two-liquid phase bioreactors: high-performance operation based on the use of hydrophobic biomass. Biochemical Engineering Journal 70:9-16.

Muñoz R, Daugulis AJ, Hernandez M, Quijano G (2012a) Recent advances in two-phase partitioning bioreactors for the treatment of volatile organic compounds. Biotechnology Advances 30:1707-1720.

Hernandez M, Quijano G, Muñoz R (2012) Key role of microbial characteristics on the performance of VOC biodegradation in two-liquid phase bioreactors. Environmental Science & Technology 46:4059-4066.

Hernandez M, Quijano G, Muñoz R, Bordel S (2011) Modeling of VOC mass transfer in two-liquid phase stirred tank, biotrickling filter and airlift reactors. Chemical Engineering Journal 172:961-969.

Hernandez M, Quijano G, Thalasso F, Daugulis AJ, Villaverde S, Muñoz R (2010). A comparative study of solid and liquid non-aqueous phases for the biodegradation of hexane in two-phase partitioning bioreactors. Biotechnology and Bioengineering106:731-740.

Quijano G, Rocha Rios J, Hernandez M, Villaverde S, Revah S, Muñoz R, Thalasso F (2010) Determining the effect of solid and liquid vectors on the gaseous interfacial area and oxygen transfer rates in two-phase partitioning bioreactors. Journal of Hazardous Materials 175:1085-1089.