

Removal of volatile methyl siloxanes in a two-phase partitioning bioreactor

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Keywords: multiphase bioreactor, silicone oil, volatile methyl siloxanes

Introduction. Volatile methyl siloxanes (VMS) are a group of organic compounds generated from molecules of polydimethylsiloxane during the anaerobic digestion processes, being octamethylcyclotetrasiloxane (D4) and decamethylcyclopentasiloxane (D5), the most common VMS present in biogas (1). When biogas laden with VMS is burned, silicates are formed, leading to abrasion and lubrication issues, producing irreversible damage to energy production devices (2). The benchmark technologies for MVS abatement are adsorption and absorption processes. However, these technologies are expensive and possess a large carbon footprint as they are operated at high temperature and/or pressures (3). Consequently, there is a growing interest in developing new cost-efficient, and ecofriendly technologies for VMS removal, such as biological technologies.

In the present work, a novel gas-liquid-liquid multiphase reactor using hydrophobic biomass was developed for the simultaneous removal of D4 and D5 under anoxic conditions.

Methodology. The experimental set up consisted of a 1L two-phase partitioning bioreactor operated as a stirred tank reactor in sequencing batch mode. The operating conditions consisted in a hydraulic retention time (HRT) of 10 days, gas retention time (GRT) of 45 minutes, 250 rpm and 30°C. The reactor was provided with 150 mL of silicone oil as an organic phase (i.e. 15% v/v). A N₂ gas stream laden with a mixture of D4 and D5 was fed to the reactor. Secondary activated sludge from a WWTP was used as inoculum. Seven experimental phases were tested, with the first phase serving as a control without silicone oil. Several D4 and D5 loading rates (L) were tested in the next experimental phases with the reactor supplied with silicone oil. D4 and D5 removal performance was evaluated considering the elimination capacity (EC), removal efficiency (RE) and the nitrate consumption rate (R_{NO₃}). The bacterial community was characterized in the aqueous phase and in the silicone oil by sampling the reactor at days 0, 20 and 127.

Results. In the experimental phase I operated only with aqueous medium, RE values of 26.7 and 24.1% for D4 and D5 (corresponding to EC values of 539 and 836 mg m⁻³ h⁻¹) were determined, respectively. Once silicone was added to the reactor in the experimental

phase II, hydrophobic biomass was progressively enriched due to the sequencing batch operation. Under these conditions, an enhanced removal performance of D4 and D5 was observed. The maximum siloxanes removal performance was achieved in the experimental phase VII for D4 and VI for D5, supporting RE values of 66.3 and 91.8% for D4 and D5 (corresponding to EC values of 1345 and 1135mg m⁻³ h⁻¹), respectively. Likewise, a maximum R_{NO₃} value of 1846 mg m⁻³ h⁻¹ was obtained in the experimental phase V. This study showed for the first time that there is a competitive inhibition between D4 and D5, predominating D5 removal over D4.

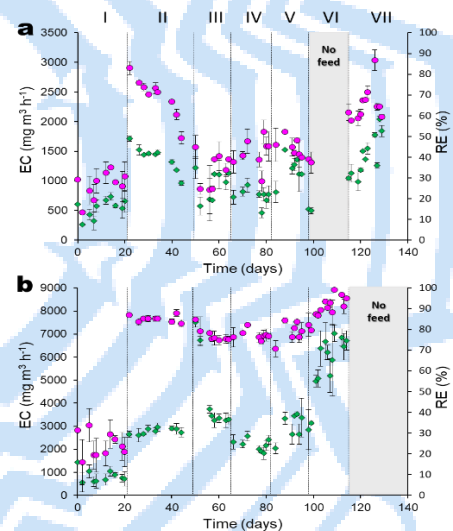


Fig. 1 Removal performance of (a) D4 and (b) D5. The elimination capacity (EC) and removal efficiency (RE) is represented by green diamonds and pink circles, respectively.

Conclusions. A competitive inhibition between D4 and D5 was confirmed. The removal efficiency of D5 in the two-phase partitioning bioreactor was always higher for D5 than that for D4.

Acknowledgements. The financial support from CONACYT (Ciencia Básica Project A1-S-10079) and DGAPA-UNAM (project PAPIIT TA100123) is gratefully acknowledged.

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