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A capillary bioreactor to increase methane transfer and oxidation through Taylor flow formation and transfer vector addition

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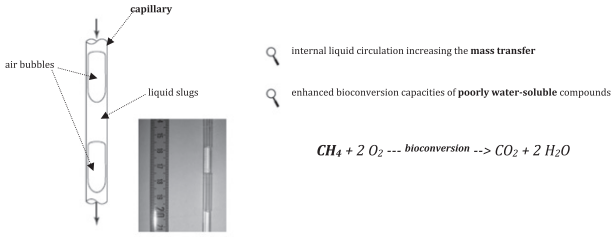
HIGHLIGHTS

- We studied methane oxidation in a capillary gas treatment bioreactor.
- A new bioreactor in which Taylor flow with transfer vector addition are combined.
- Superior mass transfer (k_La) is obtained when compared to conventional bio-contactors.
- Improved methane removal obtained when compared to conventional bio-contactors.
- A method demonstrated to improve bio-treatment of gaseous hydrophobic compounds.

GRAPHICAL ABSTRACT



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ABSTRACT

The impact of two strategies to enhance the mass transfer of hydrophobic compounds, Taylor flow (or segmented flow) and the addition of an organic transfer vector (silicone oil), were investigated under abiotic and biotic conditions in a capillary bioreactor. The capillary bioreactor consisted of a capillary column (where Taylor flow was produced in a gas/liquid flow) and a gas–liquid separator at the outlet of the capillary column which was operated as a stirred tank with superficial aeration. It was shown that the system was limited by mass transfer and not by the biological reaction. Taylor flow in the capillary resulted in an increase of up to two orders of magnitude for the volumetric oxygen transfer coefficient (k_La) when compared to the coefficient for the gas–liquid separator, or values previously obtained in other turbulent contactors. The bioconversion rates of methane in the capillary column where found to be significantly higher than for conventional systems. Silicone oil addition increased k_La up to 38% in the gas–liquid separator, but reduced it with 38% in the capillary. Contrary to observations during abiotic k_La determinations, silicone oil addition increased the CH_4 removal and O_2 consumption by the methanotrophic consortium in both, gas–liquid separator and capillary. Increased gas flow rate gave an 19% increase in methane removal in the capillary bioreactor, an additional increase of 8% was obtained adding 5% of silicone oil at the same flow, while an additional increase of 47% was obtained adding 10% of silicone oil at the same flow with inoculum pre-adapted to transfer vector. The contribution of the capillary channel to the overall methane removal in the system was high considering that the volume of this channel was just 0.64% of the total volume in the bioreactor, indicating a good potential of further optimization of the reactor system.

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