Semana de Engenharia 2010
Guimarães, 11 a 15 de Outubro

AEROBIC GRANULATION KINETICS, STOIQUIOMETRICS AND MORPHOLOGICAL ASSESSMENT

Catarina S Oliveira[1], Frédéric Thalasso[2] and Madalena Alves[1]
[1] IBB- Institute for Biotechnology and Bioengineering,
Centre of Biological Engineering, University of Minho,
Campus de Gualtar, 4710-057 Braga, Portugal.
[2] Centro de Investigación y de Estudios Avanzados del IPN,
Mexico City, Mexico.
E-mail: catarinaoliveira@deb.uminho.pt

KEYWORDS

Pulse respirometry, quantitative analysis, sequencing batch airlift reactor.

ABSTRACT (100-200 words)

In the present work, aerobic granulation of activated sludge was achieved in a sequencing batch airlift reactor (SBAR) fed with acetate as sole carbon source. Aerobic granulation process was followed by the assessment of the biomass kinetic and stoichiometric parameters through respirometric pulse experiments, and by the assessment of aggregates morphology through quantitative image analysis.

This study contributes for a better understanding of the aerobic granulation process, introducing tools for aerobic granular biomass characterisation.

INTRODUCTION

Aerobic granular sludge has recently become a promising environmental biotechnology process for wastewater treatment. Understanding the aerobic granulation process in all its facets is, therefore, of major importance.

Quantitative image analysis is nowadays a powerful and well established tool for monitoring activated sludge processes.

Pulse respirometry is the measurement of the biological oxygen consumption rate when a define amount of substrate (pulse) is injected into the system, under well defined conditions. Respirometry has been proven to be a simple and useful tool for stoichiometric and kinetic parameters estimation.

In the present work these two techniques, quantitative image analysis and pulse respirometry, were applied for monitoring the aerobic granulation process.

MATERIAL AND METHODS

Experimental setup

A lab-scale SBAR with a working volume of 5 L was inoculated with activated sludge from a compact wastewater treatment plant (Oliveira, Barcelos). The SBAR was operated in 4 hour cycles constituted of: a feeding phase (3 min); aeration phase (232 min); settling phase (2 min); and effluent withdrawal with 50 % volume exchange ratio (3 min). The reactor was operated for 40 days, during which it was monitored in terms of influent, effluent and biomass characterisation. Influent and effluent were characterised through the COD and suspended solids concentration measurements, according to Standard Methods (APHA, 1999). Biomass was sieved (0.250 mm) to separate micro-aggregates from macro-aggregates, i.e. granules, and each portion was characterised through: volatile suspended solids (VSS) concentration; 5 min, 10 min and 30 min sludge volume index (SVI) for estimating settling ability; quantitative image analysis for assessment of morphological changes in macro-aggregates (D > 0.2 mm); and pulse respirometry for kinetic and stoichiometric parameters estimation.

Image analysis

Image acquisition process was done in accordance with Costa *et al.* (2009). Images were saved with 768×576 pixel size in 8 bits (256 grey levels) by Image Pro Plus (Media Cybernetics, Silver Spring, MD) software package. Image processing and analysis was accomplished by means of two programmes developed inMatlab (The Mathworks, Inc., Natick, MA) by Amaral (2003) for micro and macro-aggregates.

Pulse respirometry

Respirometric experiments were performed to total biomass, and, separately, to macro-aggregates, i.e. granular biomass. Respirometric pulse experiments were done in a 0.5 L respirometer according to the procedure presented by Oliveira *et al.* (2009). The obtained respirograms allowed the direct determination of the biomass yield (Y), and by model fitting the Monod equation to the respirograms the estimation of the affinity constant (K_S) and the maximum specific oxygen uptake rate ($SOUR_{ex}max$).

RESULTS and DISCUSSION

The average COD removal efficiency was always above 90 %. Biomass concentration increased from 2.4 ± 1.3 g VSS/L to 10.4 ± 3.5 g VSS L^{-1}. Compact aggregates with granular characteristics, namely fast settling velocity (SVI_5 = SVI_{30} ≈ 50 L g^{-1}) were identified after 4 days of operation. Average diameter of macro-aggregates increased from 0.44 ± 0.02 mm to 1.41 ± 0.05 mm around day 37.

Substrate affinity constant (K_S) of the granules were higher than that of the total biomass, 43.4 and 31.3 h^{-1} respectively, this was attributed to the substrate diffusion through the granules. Stoichiometric results showed granular biomass to be the major contributor for biomass growth (Y of granular biomass was higher than Y of total biomass). The predominance of granular biomass from day 8 onward in the biomass activity was shown respirometrically by the significant contribution of the granular sludge to the total $SOUR_{max}$ (Figure 1).

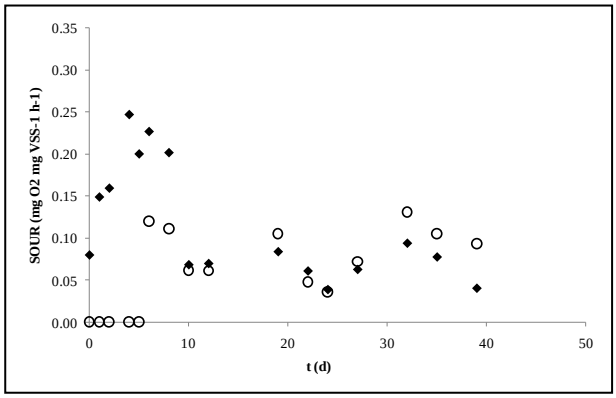

Figure 1. Time course of the maximum specific oxygen uptake rate ($SOUR_{max}$) of the total biomass (♦) and granular biomass (o)

CONCLUSIONS

Respirometry and image analysis proved to be powerful tools for the study of aerobic granulation, allowing biomass characterisation in terms of kinetics and stoichiometrics, and quantitative morphology, respectively.

REFERENCES

Amaral AL. (2003) Image analysis in biotechnological processes: application to wastewater treatment. PhD thesis, University of Minho, Braga, Portugal.

APHA. (1999) Standard methods for the examination of water and wastewater. 20th Edn. Washington, DC, American Publishers Health Association.

Costa JC, Moita I, Ferreira EC, Alves MM. (2009) Morphology and physiology of anaerobic granular sludge exposed to an organic solvent. Journal of Hazardous Materials 167: 393–398.

Oliveira CS, Ordaz A, Alba J, Alves M, Ferreira EC, Thalasso F. (2009) Determination of kinetic and stoichiometric parameters of *Pseudomonas putida* F1 by chemostat and *in situ* pulse respirometry. Chemical Product and Process Modeling 4(2): article 2.

AUTHOR BIOGRAPHIES

CATARINA S OLIVEIRA

2003. Graduation at Biological Engineering, UMinho

2004-2006. Researcher in the ONCOFIRE - Online Control of Fixed Bed Reactors project

2007. Start Ph.D. in Chemical and Biological Engineering, UMinho and Cinvestav.

FRÉDÉRIC THALASSO

1993. PhD in Biotechnology, Université catholique de Lovain, Belgium.

National Researcher Level II

MADALENA ALVES

1987. Graduation in Chemical Engineering, FEUP.

1992. Master in Biotechnology (Biochemical Engineering), IST.

1998. PhD in Chemical and Biological Engineering, UMinho.

1998-2005. Associate Professor, UMinho

2005. Assistant Professor, UMinho.