Chemical Engineering Journal 218 (2013) 368–375

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Growth limiting conditions and denitrification govern extent and frequency of volume detachment of biofilms

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HIGHLIGHTS

- ▸ We investigated the biofilm physical structure and its detachment mechanisms.
- ▸ Anoxic conditions favor the formation of homogeneous biofilm structures.
- ▸ Detachment of large particles occurs for all biofilms and dominates biomass loss.
- ▸ An increasing roughness induces an increase in the size of detached particles.
- ▸ Biofilm models should consider discrete volume detachment of large particles.

ARTICLE INFO

Article history:
Received 7 June 2012
Received in revised form 30 October 2012
Accepted 14 November 2012
Available online 8 December 2012

Keywords:
Biofilm structure
Detachment mechanisms
Particles size distributions
Volume detachment
Growth conditions

ABSTRACT

This study aims at evaluating the mechanisms of biofilm detachment with regard of the physical properties of the biofilm. Biofilms were developed in Couette–Taylor reactor under controlled hydrodynamic conditions and under different environmental growth conditions. Five different conditions were tested and lead to the formation of two aerobic heterotrophic biofilms (aeHB1 and aeHB2), a mixed autotrophic and heterotrophic biofilm (MAHB) and two anoxic heterotrophic biofilms (anHB1 and anHB2). Biofilm detachment was evaluated by monitoring the size of the detached particles (using light-scattering) as well as the biofilm physical properties (using CCD camera and image analysis). Results indicate that volume erosion of large biofilm particles with size ranging from 50 to 500 μm dominated the biomass loss for all biofilms. Surface erosion of small particles with size lower than 20 μm dominates biofilm detachment in number. The extent of the volume detachment events was governed by the size of the biofilm surface heterogeneities (i.e., the absolute biofilm roughness) but never impacted more than 80% of the mean biofilm thickness due to the highly cohesive basal layer. Anoxic biofilms were smoother and thinner than aerobic biofilms and thus associated with the detachment of smaller particles. Our results contradict the simplifying assumption of surface detachment that is considered in many biofilm models and suggest that discrete volume events should be considered.

1. Introduction

Detachment is a key process in biofilm systems that influences pathogen spreading [1], release of particles that have detrimental effects on production systems and/or on water quality [2], the extent of biofouling [3] or also system performances [4]. But the mechanisms of biofilm detachment are not well understood and still need to be evaluated for further improved modeling of biofilm systems [5]. To what extent are different physical structures of biofilms associated with similar detachment mechanisms is not clear. Detachment process also governs the distribution of the Solid Residence Time (SRT), which controls the growth of slow-growing bacteria and in turn the biodegradation rates [4,5]. Evaluating and understanding the detachment mechanisms is thus required to better predict the spatial distribution of the microbial population and their associated microbial activities.

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1385-8947/$ - see front matter
http://dx.doi.org/10.1016/j.cej.2012.11.061