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Production of xenobiotic degrader for potential application in bioaugmentation

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HIGHLIGHTS

- ▶ Proficient xenobiotic degraders were cultivated in chemostats fed the xenobiotic.
- ▶ Short mean-cell-residence-time enhances degrader production.
- ▶ Feeds of xenobiotic with biogenic substrates increase biomass and also degrader yield.
- ▶ Biogenic/xenobiotic ratio and residence-time control economical degrader production.
- ▶ Chemostat produces degrader suitable for use in continuous bioaugmentation.

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ABSTRACT

Continuous-flow chemostats were operated at different mean-cell-residence-times (θc) and influent concentrations of a xenobiotic (2,4-D) and biogenic substrates. Steady state chemostat biomasses' performances in 2,4-D degradation were analyzed with a mathematical model to determine the quantities of degrader the biomasses contained. The qualification for microbial cells to become degraders is a high grade of degradation kinetics. This qualification uniformly applies to all biomasses. The quantities of degraders vary inversely with the chemostats' θc. Biogenic substrates increase degrader yield such that a high biogenic and a high xenobiotic influent optimize degrader mass output. Economics evaluation performed around the optima finds the influent containing 5–25% 2,4-D carbon (TOC) in approximately 900 mg/l biogenic TOC, and the θc of 2–5 d, are suitable operating conditions for a degrader producing bioreactor that may serve as a selector of biomass for bioaugmentation purposes.

1. Introduction

Many industrial organic products today are composed of molecular structures that are different from natural microbial substrates or the metabolic intermediates of natural substrates. The un-natural characteristics make those man-made organic chemicals foreign to the biosphere and thus the organics are called xenobiotics. The susceptibility to biodegradation of these xenobiotic organics varies from persistent to recalcitrant (Olaniran and Igbinosa, 2011). The short exposure period of xenobiotics to potential bacterial degraders, coupled with the un-natural compound structure, often precludes indigenous microorganisms of the genetic coding for xenobiotic metabolism (Alexander, 1973). In spite of many obstacles, most of the xenobiotic organic compounds can become biodegradable after a bacterial population has gained degradation capability through the process of acclimation (Buitron et al., 1998; Singleton, 1994). Through acclimation, some or all microbial cells develop the capability of xenobiotic degradation and the indigenous cells are converted into degraders (Chong, 2005). In a mixed culture system, a continuous influent of a xenobiotic serves as a continuous acclimation stress and thus the system can maintain an amount of degrader while non-degraders survive from scavenging the metabolites of the xenobiotic. The quantity of degrader converted may vary with culturing conditions and the nature of their previous encounter with the xenobiotic compound (Chong and Chen, 2007; Chong et al., 2012).

The efficiency of an activated sludge treatment plant in treating xenobiotic influent depends on the sludge's capability to degrade the xenobiotic. The capability is described by the quantity of degrader (capable sludge) present in the sludge, in addition to the degradation kinetics of the degraders. There are instances in which a treatment plant fails its xenobiotic treatment because the plant contains insufficient xenobiotic degraders: (1) During reactor startup, the biogenic grown activated sludge had not been acclimated; and (2) at periodic xenobiotic influent, the previously capable degraders may have de-acclimated or out-dominated during the time when the xenobiotic was absent from the influent. To improve the performance of an activated sludge plant, bioaugmenting the plant is found effective with microbial biomass

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