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Analysis of microbial characterization in an upflow anaerobic sludge bed/biological aerated filter system for treating microcrystalline cellulose wastewater

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HIGHLIGHTS

- An UASB-BAF system was used for treating MCC wastewater.
- Microbial characterization in this MCC wastewater treatment process.
- The total MCC degradation efficiency of the UASB-BAF system was above 70%.
- Cellulolytic microorganisms were dominant in the first stage UASB-BAF.
- *Cel6B* was the rate-limiting enzyme gene of MCC degrading in the UASB-BAF bioreactor.

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ABSTRACT

A two-stage UASB and 2-stage BAF series bioreactor was used for treating the microcrystalline cellulose (MCC) wastewater. The treating efficiency, dominant microbes, eubacterial and archaebacterial composition and *cel5*A, *cel6*B and *bgl*C gene expression levels were examined using combined PCR-DGGE and real-time PCR technology. The results showed that under three MCC loads (1000, 2000 and 3000 mg L^{-1}), the total MCC degradation efficiency of the UASB-BAF system was 82.0%, 83.5% and 70.5%, respectively. In different MCC load cases, the first stage UASB and BAF formed an approximate full-value cellulase system where cellulolytic microorganisms were the dominant flora, while the second stage UASB and BAF formed a low-value cellulase system where non-cellulolytic microorganisms were the dominant flora. Eubacteria were dominant in every UASB-BAF unit. The rate-limiting enzyme gene for MCC degradation in every unit was *cel6*B. These results will support the development of high efficiency bio-reactors for the degradation of MCC.

1. Introduction

Microcrystalline cellulose (MCC) is a product prepared by depolymerization of natural cellulose. MCC is used in a number of ways, including as an excipient or inert carrier for the active ingredient of a medication in tablet form in pharmaceuticals, a health food additive, a thickener and emulsifier of water-based coatings and cosmetics, and a tackifier and filler for leather surface smoothing (Lynd et al., 2002; O'Sullivan, 1997). These industrial applications produce wastewater containing MCC, potentially harming the environment and human health (Kortekaas et al., 1998). In order to eliminate the potential harm, researchers in environmental biotechnology and water treatment fields have developed a variety of biological wastewater treatment processes specifically for MCC wastewater. Bioreactor processes are widely used world-wide because of their low cost and high degradation efficiency (Kortekaas et al., 1998).

Cellulose is a polycrystalline molecule with both crystalline and amorphous regions. The crystallinity index is used to measure the proportion of crystalline regions in cellulose (Weimer et al., 1990). The crystallinity index is the determining factor for cellulose hydrolysis rates, regardless of the enzyme concentration or microbial cell concentration. The higher the crystallinity index of the cellulose substrate, the more difficult the degradation (Weimer et al., 1990). MCC is a kind of cellulose with a high crystallinity index ranging from 70% to 80% (Bansal et al., 2010). The compound is often used to evaluate the activity of crystalline cellulose degrading enzymes (Mandels et al., 2009) and the cellulose-degrading ability of a microorganism (Hamilton-Brehm et al., 2010). MCC is not able to enter cellulose-degrading microbial cells, rather the degradation occurs extracellularly and is catalyzed by secreted cellulases

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