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Fractionation and characterization of dissolved extracellular and intracellular products derived from floccular sludge and aerobic granules

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HIGHLIGHTS

- Dissolved polymers are extracted and fractionated based on hydrophobicity.
- Aerobic granules contain lower amounts of dissolved polymers than floccular sludge.
- Proteins and polysaccharides mainly exist as colloids form in granular EPS.
- Dissolved polymers become more humified and hydrophobic after sludge granulation.
- Fluorescence characteristics between floccular and granular sludge are different.

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ABSTRACT

Dissolved extracellular and intracellular polymeric substances (DEPS and DIPS) from floccular sludge and aerobic granules were extracted and fractionated based on compound hydrophobicity. Compared with floccular sludge, aerobic granules contained lower amounts of DEPS and DIPS. Fourier transforms infrared spectra suggested that large amounts of proteins and polysaccharides existed in colloidal form in the extracellular polymeric substances of aerobic granules. Fluorescence excitation-emission matrix spectra revealed that tightly bound DEPS (TB-DEPS) and DIPS were humified after sludge granulation. Meanwhile, the proportions of hydrophilic contents in the TB-DEPS and DIPS fractions decreased from 45.3% to 28.3% and from 40.1% to 18.9%, respectively. These data indicated that TB-DEPS and DIPS from aerobic granules were more hydrophobic than those from floccular sludge. The results of the hierarchical cluster analysis further confirmed that the characteristics of dissolved organic matters between floccular and granular sludge were distinctly different.

1. Introduction

Aerobic granulation, as a promising biotechnology for wastewater treatment, has attracted intensive research attention (Adav et al., 2008; Xu et al., 2010). Extracellular polymeric substances (EPS), which fill and form the space between microbial cells, are produced by microorganisms in aerobic and anaerobic sludge when organic materials present in wastewater are consumed. EPS are known to play a crucial role in the formation of microbial aggregates, adhesion to surfaces, and flocculation (Wingender et al., 1999; Sheng et al., 2010), as well as in the building and maintenance of the structural integrity of aerobic granules during wastewater treatment. EPS are composed of a variety of organic substances, including polysaccharides (PS), proteins (PN), nucleic acids, lipids, and humic acids (Ni et al., 2008; Sheng et al., 2008). PS and PN have been recognized as major constituents of EPS (Wilen et al., 2003; Ras et al., 2008); the amounts and the nature of these biopolymers strongly influence the floc structure and sludge properties (surface charge, hydrophobicity). Meanwhile, the sludge EPS mainly derive from the metabolism of microorganisms and relate to the transfer of the intracellular polymeric substances (IPS) of these microorganisms. Therefore, characterizing EPS and IPS is important to better understand the role of EPS in activated sludge and aerobic granulation.

Some studies divided EPS into two major fractions based on extraction methodology: soluble EPS and bound EPS (Yu et al., 2008a,b). The soluble EPS, also called the slime, can move freely between sludge flocs and the surrounding liquor, whereas the bound EPS form a discrete covering layer with a distinct margin outside all cell walls. In addition, the bound EPS exhibit a dynamic double-layer structure, which can be classified as loosely bound EPS

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