Component analysis of extracellular polymeric substances (EPS) during aerobic sludge granulation using FTIR and 3D-EEM technologies

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Highlights

- FTIR and 3D-EEM are used to analyse the main components of EPS in aerobic granule.
- Results indicate the importance of aromatic protein-like substances in the stable granular sludge.
- The isomers of carbohydrates (1110–1047 cm⁻¹) can be attributed to the aerobic sludge granulation.

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Abstract

In recent years, lots of the extracellular polymeric substances (EPS) related researches have focused on its role in the granulation and structural stability of aerobic sludge. Three-dimensional fluorescence spectrum (3D-EEM) and fourier transform infrared spectroscopy (FTIR) technologies were used to analyse the main components of sludge EPS during aerobic sludge granulation in this study. Results showed that the components of sludge EPS tended to be stable during aerobic sludge granulation. The peak F (Ex/Em = 230/308.5) from 3D-EEM and the predominant spectral band at approximately 1517 cm⁻¹ from the FTIR spectra of the matured granular sludge indicated the importance of aromatic protein-like substances together, especially tyrosine in maintaining the stable structure of the granular sludge. Furthermore, the differences in the occurrence position and frequency of C–O bonds (1110–1047 cm⁻¹) observed during aerobic sludge granulation showed that the transformations between the isomers and other forms of carbohydrates may be attributed to the formation of aerobic granule.

1. Introduction

Aerobic granule is a class of microbial aggregates with a compact physical structure that favours high biomass concentration in bioreactors and excellent settleability to simplify effluent separation (Adav et al., 2008a; Ni et al., 2009a,b; Su et al., 2012). Due to these unique properties, aerobic granulation technology has been applied widely in the treatment of high strength wastewater containing organics, nitrogen, phosphorus and other toxic substances (de Kreuk et al., 2005; Yilmaz et al., 2008; Zhu et al., 2008; Wu et al., 2010). Actually, the formation of aerobic granule is complicated, and many mechanisms of aerobic sludge granulation such as the microbial self-immobilisation hypothesis, filamentous hypothesis and extracellular polymeric substances (EPS) hypothesis have been put forward in recent years (Li and Tay, 2002; Li et al., 2006; Du et al., 2011). Thereinto, some of the above hypotheses have been well elucidated and applied in related studies. Taking the microbial self-immobilisation hypothesis for example, the procedure is as follows: physical agitation to initiate bacterium-to-bacterium contact; physical, chemical or biochemical interactions to keep a stable bacteria–bacteria interface and multicellular contact; microbial interaction to induce the maturation of aggregate microorganisms; and hydrodynamic shear force to stabilise the three-dimensional structure of the aerobic granule. Even so, the EPS hypothesis has drawn more and more attention in recent years because of the important position and function of EPS in activated sludge (Neyens et al., 2004; McSwain et al., 2005; Adav et al., 2008b).

Up to date, lots of the EPS related researches have focused on its role in sludge granulation and granular stability (Quarmby and Forster, 1995; Tay et al., 2001; McSwain et al., 2005; Wang et al., 2005; Chen et al., 2007). However, the key components of EPS in granular sludge are still not well recognised. The distribution of several EPS key components, such as proteins, lipids, α- and β-polysaccharides, and cells, has been studied using confocal laser scanning microscopy (CLSM) coupled with a multicolour fluorescent technique by researchers (McSwain et al., 2005; Adav et al.,...