Membrane biofouling mechanism in an aerobic granular reactor degrading 4-chlorophenol

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ABSTRACT

The membrane fouling of an aerobic granular reactor coupled with a submerged membrane in a sequencing batch reactor was evaluated. The fouling analysis was performed by applying microscopy techniques to determine the morphology and structure of the fouling layer on a polyvinylidene fluoride membrane. It was found that the main cause of fouling was the polysaccharide adsorption on membrane surface, followed by the growth of microorganisms to form a biofilm.

Key words | 4-chlorophenol, aerobic granules, fouling, membrane, SBR

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INTRODUCTION

Aerobic granules are aggregates of microbial origin, which do not coagulate under reduced hydrodynamic shear, and which settle significantly faster than activated sludge flocs (de Kreuk *et al.* 2007). Aerobic granules in an aerobic SBR have several advantages compared to conventional activated sludge in the case of toxic compounds degradation Arrojo *et al.* 2004). It has been proposed that the combination of aerobic granular biomass and submerged membrane bioreactor (MBR) (Li *et al.* 2005), reduce the membrane fouling by taking advantage of the physical properties of the granules. Previously, there are reports that state that although the fouling is delayed when granular sludge is used, a higher irreversible fouling than conventional activated sludge is produced (Wang *et al.* 2008), resulting in a lack of total recovery of the membrane permeability after chemical washing (Zhou *et al.* 2007). Juang *et al.* (2010a, 2010b), reported the presence of an internal bacterial biofilm as a possible factor responsible for the fouling of hollow fiber membranes.

The fouling of the membranes in a submerged MBR is principally caused by the deposition of extracellular polymeric substances (EPS), together with the biomass forming the biocake which blocks the filtering (Chen *et al.* 2006a). These exopolymers are formed by proteins and polysaccharides as well as by humic substances, lipids and nucleic acids, in a lower concentration. However, it is unclear about the role played by these substances in the development of the fouling layer throughout time. To determine the biofouling mechanism it is necessary to determine the presence of the different substances, such as EPS, on the membrane surface and pores. This analysis can be done by applying some microscopy techniques (Chen *et al.* 2007). In this sense, the use of fluorescence microscopy and confocal laser scanning microscopy (CLSM) as tools to analyze the structures and bacterial biofilms formation, and the presence of exopolymeric substances in bio-cakes on membrane surfaces is well recognized.

The fluorophores used in microscopy analysis are fluorescent molecules that possess reactive groups which covalently and specifically bind to compounds of interest (e.g. isothiocyanate esters, and pentafluorophenyl succinimidyl present in certain fluorochromes) and react with the amino groups contained in some macromolecules (Adav *et al.* 2010). Different fluorochromes, with different excitation wavelengths, can be used to stain the total cells, dead cells, proteins, lipids, and EPS in bioaggregates. Using staining techniques, Chen *el al.* (2006b) found that β-polysaccharides are mostly present near to the membrane

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