Removal of inhibitory phenolic compounds by biological activated carbon coupled membrane bioreactor

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Abstract Phenolic compounds cause problems for conventional treatments due to their toxic and inhibitory properties. This work investigated the treatability of phenolic compounds by using two membrane-bioreactor systems, namely: activated sludge coupled with MBR (AS-MBR) and biological granular activated carbon coupled with MBR (BAC-MBR). Initially, the system was fed with phenol (500 mg/L) followed by adding 2,4-dichlorophenol (2,4-DCP). Phenol, 2,4-DCP, TOC and COD removal were higher than 98.99% when the organic load ranged between 1.80 and 5.76 kg/m^3.d COD. In addition to MBR system development, removal mechanisms were also investigated. Relatively low values of phenol adsorption of GAC and biomass, and high maximum substrate removal rates obtained from a biokinetic experiment, proved that the removals were mainly due to biodegradation. Analysis of sludge indicated a significant difference in the sludge characteristics of the two reactors. The high EPS content in BAC-MBR led to higher viscosity and poor sludge settling properties. The relationship between sludge properties and EPS components revealed that settleability had no direct correlation with EPS, though it was better correlated to protein/carbohydrate ratios.

Keywords Biological granular activated carbon; membrane bioreactor; phenol; sludge properties

Water Science & Technology **Vol 53 No 11 pp 89–97** © IWA Publishing 2006

Introduction

Phenol and 2, 4-dichlorophenol are found in wastewater from oil refineries, petrochemical units, pharmaceutical, pesticide, petrochemical plants, etc. Treatment of these toxic compounds has been studied by using sequencing batch reactors (SBR) (Young and Lant, 2001), activated carbon adsorption and SBR coupled with granular activated carbon (Vininthanthrat, 1999; Buitron *et al.*, 2001). However, in order to meet discharge standards, conventional biological treatments have their own difficulties, such as sludge deflocculation, process instability (Galil *et al.*, 1998) resulting from inhibitory properties to microorganisms of phenols.

In recent years, the membrane bioreactor (MBR) process has been applied widely in wastewater treatment, i.e. municipal wastewater, high molecular weight compounds and oily wastewater (Tellez *et al.*, 2002). High quality effluent and stability, small size of treatment unit, less sludge production, and flexibility of operation are advantages of MBR (Visvanathan *et al.*, 2000). However, MBRs are unable to remove low molecular weight cut-off (MWCO) organic matters. Modifications of MBR have been studied to improve permeate quality. Some researchers have proposed the addition of powdered activated carbon (PAC) in MBR (Pirbazari *et al.*, 1996). The process is the so-called biological activated carbon coupled MBR (BAC-MBR). Because activated carbon absorbs MWCO organic matters and functions as the medium for attached bacterial growth, BAC-MBR has proved to increase permeate quality (Matsui *et al.*, 2001). Although BAC-MBR has been applied in various wastewater treatments, little has been studied on toxic and inhibitory phenolic wastewater.

doi: 10.2166/wst.2006.341