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Removal of H_2S in down-flow GAC biofiltration using sulfide oxidizing bacteria from concentrated latex wastewater

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ABSTRACT

A biofiltration system with sulfur oxidizing bacteria immobilized on granular activated carbon (GAC) as packing materials had a good potential when used to eliminate H_2S. The sulfur oxidizing bacteria were stimulated from concentrated latex wastewater with sulfur supplement under aerobic condition. Afterward, it was immobilized on GAC to test the performance of cell-immobilized GAC biofilter. In this study, the effect of inlet H_2S concentration, H_2S gas flow rate, air gas flow rate and long-term operation on the H_2S removal efficiency was investigated. In addition, the comparative performance of sulfide oxidizing bacterium immobilized on GAC (biofilter A) and GAC without cell immobilization (biofilter B) systems was studied. It was found that the efficiency of the H_2S removal was more than 98% even at high concentrations (200–4000 ppm) and the maximum elimination capacity was about 125 g $H_2S/m^3$of GAC/h in the biofilter A. However, the H_2S flow rate of 15–35 l/h into both biofilters had little influence on the efficiency of H_2S removal. Moreover, an air flow rate of 5.86 l/h gave complete removal of H_2S (100%) in biofilter A. During the long-term operation, the complete H_2S removal was achieved after 3-days operation in biofilter A and remained stable up to 60-days.

1. Introduction

Anaerobic treatment of concentrated latex wastewater, which is sulfate-rich wastewater, can generate hydrogen sulfide (H_2S) as a by-product in biogas. H_2S is produced naturally during the reduction of sulfate and sulfur-containing organic compounds by anaerobic bacteria. H_2S is a colorless, toxic, flammable gas that is responsible for the foul odor of rotten eggs, an odor that is a major nuisance in municipal, industrial and biological wastewater treatment systems. H_2S is extremely toxic to living organisms and plants. At a level of 0–5 ppm in the air, it can be detected easily. At levels greater than 10 ppm it can affect human health, while levels of more than 600 ppm can cause death (Droste, 1997).

Biofiltration has recently been recognized as one of the most popular and efficient technologies for odor treatment. A typical biofiltration process consists of two steps. Firstly, the pollutant is transferred from the air stream into liquid film and adsorbed on a solid medium; then the pollutant is biodegraded by microbes living in the liquid phase or on the packing material. Therefore, the operating conditions of the biofilter, supporting material, and inoculated microbes are important parameters to consider (Duan et al., 2007). Recently, cell-immobilized biofiltration has become one of the most important biological processes for treating H_2S gases. This process has low capital and operating costs for its regeneration and recirculation. Moreover, it requires less energy and no additional chemicals or fuels. Above all, it was public acceptance as an environment-friendly process for reducing secondary pollution (Ma et al., 2006a). Several different packing materials have been used in biofiltration for the removal of H_2S. However activated carbon has been recognized as the most extensively used material, due to its capacity for adsorbing substrates quickly and then slowly releasing them for microbial degradation (Duan et al., 2005b). The major function of activated carbon is to support the microorganisms and act as a buffer for fluctuating loading (Duan et al., 2005a). The immobilization of microorganisms to activated carbon in biofiltration is the self-attachment of the microorganisms to the filter, which is defined as attached growth system. The advantages of attached microbial film compared to suspended microorganisms are higher biomass concentrations, higher metabolic activity and greater resistance of toxicity (Cohen, 2001).

It has been reported that various sulfide oxidizing bacterium, including *Thiobacillus*, *Xanthomonas* and *Pseudomonas* have great potential to metabolize H_2S effectively for its low acid production and fast oxidation rate in activated carbon (Ma et al., 2006a, 2006b; OyarzÚn et al., 2003; Chung et al., 1996b). Most researches

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studied H_2S removal using one microorganism immobilized on carrier (Ma et al., 2006a, 2006b; Son and Lee, 2005; OyarzÚn et al., 2003; Chung et al., 1996b). However, there are limitations on employing pure cultures for concentrated latex industrial application to remove H_2S using biofiltration. Although some researches used mixed culture from compost (Morgan-Sagastume and Noyola, 2006) and wastewater treatment plant sludge (Duan et al., 2006; Kim et al., 2008), there are still a lot of microbial diversity in different sources. In addition, the microorganisms from sulfate reduction tank of concentrated latex industry for H_2S removal have never been reported.

Therefore, this research used sulfide oxidizing bacteria obtained from concentrated latex wastewater. The performance of biofiltration system using cell-immobilized granular activated carbon (GAC) was investigated. The objectives of this research were to determine the optimum operating parameters, including inlet H_2S concentration, H_2S gas flow rate, air flow rate and long-term operation.

2. Methods

2.1. Microorganisms and cell immobilization on GAC

Sulfide oxidizing bacteria were stimulated from concentrated latex wastewater with 2.21 g sulfur supplement under aerobic condition for 3 days. For cell immobilization, commercial granular activated carbon (GAC) was selected as the support material. GAC was sieved to obtain the particle size of 6–7 mesh (2.83–3.36 mm). After microbial stimulation process, sulfide oxidizing bacteria were harvested by centrifugation (8000 rpm for 10 min). Then, the pallet was put into a 5 l plastic tank containing 3 l sterile concentrated latex wastewater. At the same time, 500 g GAC was added into for microbial attachment. The cultivation was conducted under aerobic condition. During the cultivation period, the cultured liquid in plastic tank was removed and then new sterile concentrated latex wastewater was replaced every 3 days. The cell numbers of microbial immobilization on GAC were estimated everyday by the traditional plate-counting method using a thiosulfate mineral medium. After 15 days, the microorganisms immobilized on GAC reached 4.0×10^8 cfu/g dry GAC. Then the cell-immobilized GAC was transferred into biofilters.

2.2. Thiosulfate mineral medium

Thiosulfate mineral medium, which is a selective medium for sulfide oxidizing bacteria, contained the following (g/l): 2.0 KH_2PO_4, 2.0 K_2HPO_4, 0.4 NH_4Cl, 0.2 $MgCl_2 \cdot 6H_2O$, 0.01 $FeSO_4 \cdot 7H_2O$ and 8.0 $Na_2S_2O_3 \cdot 5H_2O$ (Jin et al., 2005a). It was used for cell number estimation and isolation of sulfide oxidizing bacterium. Also, it was employed as the solution for humidification in biofilters.

2.3. Experiment setup and operation

The experiment was performed in two laboratory-scale downflow biofilters (Fig. 1). Each biofilter was made of stainless steel, with 0.055 m inner diameter and 0.6 m height (a working volume of 1 l). One biofilter was packed with 40 cm of cell-immobilized GAC (biofilter A) and another was packed with 40 cm of the GAC without cell immobilization (biofilter B). A packed bed volume in biofilters was 0.67 l (about 400 g wet weight of GAC). Air was supplied with an air compressor, with flow rate controlled by flow meter. The air was passed through a column of the thiosulfate mineral medium for humidification. Humid air was then mixed with H_2S

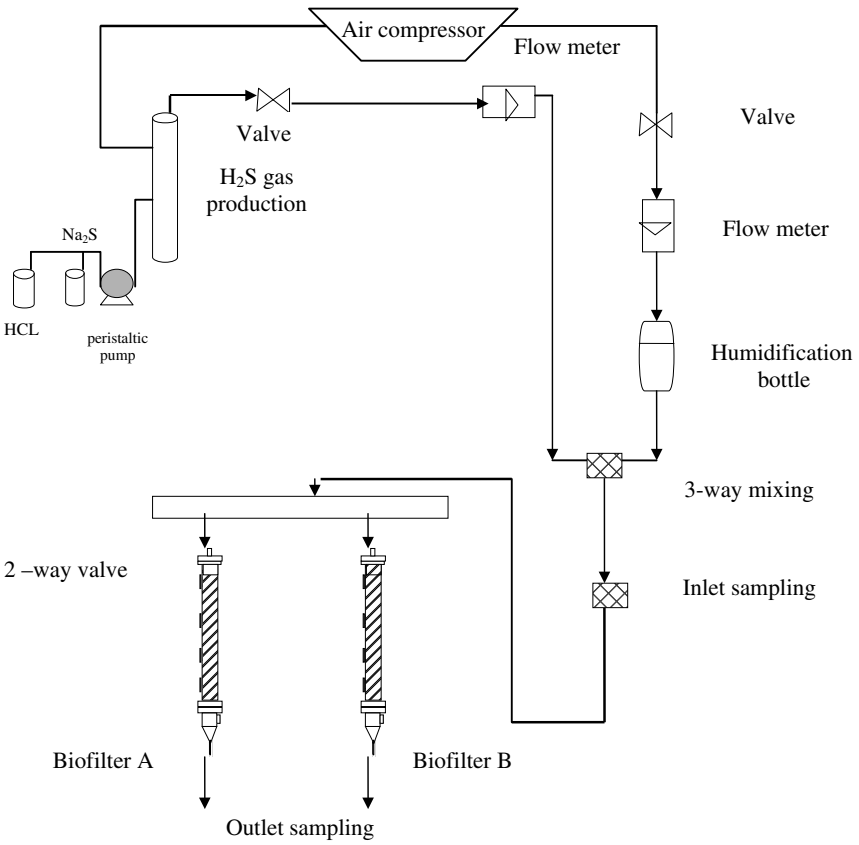

Fig. 1. Laboratory-scale experimental biofiltration system.