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Experimental and modeling study on nitric oxide removal in a biotrickling filter using *Chelatococcus daeguensis* under thermophilic condition

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HIGHLIGHTS

- Biotrickling filter inoculated with *C. daeguensis* TAD1 for NO removal is achieved under aerobic condition at 50 °C.
- Mathematical model method is employed to describe the detailed mechanisms for NO removal in BTF.
- Gaseous chemical oxidation for NO removal is coupled which is not considered in present BTF models.

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ABSTRACT

In this study, the development of a thermophilic biotrickling filter (BTF) system to inoculate a newly isolated strain of *Chelatococcus daeguensis* TAD1 for the effective treatment of nitric oxide (NO) is described. It was successfully started up in 35 days and effectively removed NO from the oxygen contained simulated gas at 50 °C. A mathematical model based on the mass transfer in gas–biofilm interface and chemical oxidation in gas phase was developed. Steady-state experimental data under different inlet NO concentration and empty bed retention time (EBRT) condition were used to verify the proposed model. The model can well reproduce the experimental results and the sensitivity analysis demonstrates that the model is not dependent on the accuracy of the parameters excessively.

1. Introduction

Increasing emission of nitrogen oxides (NOx) from various industrial processes and transportation activities, especially coal-fired power plants, are widely regarded as risks to global environment and human health (Barnes et al., 1995). Nitric oxide (NO), the major NOx component (Nagase et al., 1997; Wang et al., 2006), is a precursor for tropospheric ozone depletion and the main constituent in photochemical smog (Chen et al., 2006; Gao et al., 2011). It may also react with moisture in the air to form nitrous acid, which has been implicated in acid rain (Akimoto, 2003). Although the production of NOx can be significantly reduced by combustion process control, post-combustion flue gas treatment is required to satisfy the current regulatory air standards (Wang et al., 2006). Therefore, technologies to remove NO from the effluent gas have attracted wide attention. Conventional post-combustion technologies for NOx removal include selective catalytic reduction, selective non-catalytic reduction, adsorption, scrubbing, and so forth (Chen et al., 2009). All these are effective methods, but they often suffered from some problems, such as the catalysts are easily poisoned and hazardous wastes should be disposed (Barnes et al., 1995; Bögner et al., 1995).

Bioprocesses including biotrickling filter (BTF) and biofilter are emerging post-combustion control technologies that can be used as potential alternatives for NOx containing dilute gases purification (Chen and Ma, 2006; Ramírez et al., 2009). The principle of BTF is to treat the gaseous pollutants in a packed bed of damp material on which pollutant-degrading microorganisms are attached. According to Ligy and Marc, chemolithoautotrophic organisms such as *Thiobacillus denitrificans* can reduce nitric oxide (NO) to nitrogen gas under anoxic conditions in the biotrickling filter (Philip and Deshusses, 2003). Several studies have also proven the possibility of NO removal in bioreactors at ambient temperatures. Jiang et al. have successfully isolated a new strain of *Pseudomonas putida* SB1 and achieved effective treatment for nitric oxide at ambient temperature (Jiang et al., 2009). Jun et al. have used a bench-scale anaerobic rotating drum biofilter (RDB)

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