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Investigation and optimization of the novel UASB–MFC integrated system for sulfate removal and bioelectricity generation using the response surface methodology (RSM)

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HIGHLIGHTS

- ▶ COD/sulfate ratio and HRT influence the performance of UASB–MFC system.
- ▶ Power output and sulfate removal efficiency increase first and then decrease.
- ▶ The response surface methodology is performed to optimize the system.
- ▶ The simulation is undistorted and optimized results are reliable.

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ABSTRACT

COD/sulfate ratio and hydraulic residence time (HRT), both of which influence sulfate loadings jointly, are recognized as the most two important affecting factors for sulfate removal and bioelectricity generation in the novel up-flow anaerobic sludge blanket reactor–microbial fuel cell (UASB–MFC) integrated system. The response surface methodology (RSM) was employed for the optimization of this system and the optimum condition with COD/sulfate ratio of 2.3 and HRT of 54.3 h was obtained with the target of maximizing the power output. In terms of maximizing the total sulfate removal efficiency, the obtained optimum condition was COD/sulfate ratio of 3.7 and HRT of 55.6 h. Experimental results indicated the undistorted simulation and reliable optimized results. These demonstrated that RSM was effective to evaluate and optimize the UASB–MFC system for sulfate removal and energy recovery, providing a promising guide to further improvement of the system for potential applications.

1. Introduction

Many industrial wastewaters from sources such as sugar and paper mills (Zhang et al., 2009b), contain high concentrations of biodegradable organics as well as high-strength sulfate, due to the use of sulfuric acid (Muyzer and Stams, 2008). Wastewaters containing sulfate are normally treated by physicochemical and biological methods (Pant et al., 2010; Sarti et al., 2010). The former has some limitations including relatively high costs and energy consumption, even though may be effective (Silva et al., 2002; Bayrakdar et al., 2009). On the other hand, high-efficiency anaerobic technology has been employed to treat complex wastewaters such as sulfate containing wastewater (Sarti and Zaiat, 2011), due to its low operating cost, high efficiency and small footprint (Zhang et al., 2011). However, hydrogen sulfide (H_2S) with uncomfortable odor, toxicity and corrosivity is generated during the biological process, when sulfate is reduced by the sulfate-reducing bacteria (SRB) in the anaerobic bioreactors. Sulfide can lead to poisoning *methanogens*, hence the eventual failure of the anaerobic process and even causing problems during subsequent treatment (Parkin et al., 1991). Thus sulfide as well as H_2S should be considered and handled before discharge.

Normally, the biological oxidation of sulfide to elemental sulfur (S^0) is carried out after the reduction of sulfate to sulfide in the anaerobic process (Lens et al., 1998). Aeration as well as complex operation is often needed in the biological unit. Nowadays, microbial fuel cells (MFCs), devices that use bacteria as catalysts to oxidize organic or inorganic matters and generate current, are

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