Bioresource Technology 129 (2013) 224–228

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Simultaneous anaerobic sulfide and nitrate removal coupled with electricity generation in Microbial Fuel Cell

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HIGHLIGHTS

- The MFC could remove sulfide and nitrate simultaneously from wastewater.
- The MFC generated electricity from anaerobic bioconversion of sulfide and nitrate.
- In the MFC, the electricity generation was coupled with the substrate conversion.

ARTICLE INFO

Article history:
Received 3 September 2012
Received in revised form 30 October 2012
Accepted 1 November 2012
Available online 10 November 2012

Keywords:
Microbial Fuel Cell
Graphite rod
Anaerobic sulfide and nitrite removal
Electricity generation
Substrate conversion

ABSTRACT

Two-chamber Microbial Fuel Cells (MFC) using graphite rods as electrodes were operated for simultaneous anaerobic sulfide and nitrate removal coupled with electricity generation. The MFC showed good ability to remove substrates. When the influent sulfide and nitrate concentrations were 780 mg/L and 135.49 mg/L, respectively, the removal percentages of sulfide and nitrate were higher than 90% and the main end products were nitrogen and sulfate. The MFC also showed good ability to generate electricity, and the voltage went up with the rise of influent substrate concentrations. When the external resistance was 1000 Ω, its highest steady voltage was 71 mV. Based on the linear relationship between the electrons released by substrates and accepted by electrode, it was concluded that the electricity generation was coupled with the substrate conversion in the MFC.

1. Introduction

A number of industries generate sulfide-containing waste streams, such as petrochemical plants, tanneries, viscose rayon factories etc. (Mahmood et al., 2007a). Various toxicological effects of sulfide on human health have been described elsewhere. Large volumes of wastewaters containing nitrogenous compounds are produced from industry, agriculture and housing settlements. Nitrate or nitrite can induce multidimensional hazards, such as the eutrophication of water bodies (Zheng et al., 2004). Untreated discharge of these wastewaters to the environment can lead to serious environmental problems. Hence, its removal from wastewaters is required from an environmental standpoint (Pikaar et al., 2011).

As alternatives for oxygen, nitrate can be used to control sulfide generation during treatment of S-containing wastewaters (Cirne et al., 2008). Compared to oxygen, nitrate has the advantage of being highly soluble. This means that its use does not require applying an external gas flow and, consequently, there will be less stripping of gaseous sulfide. For such reasons, the simultaneous anaerobic sulfide and nitrate removal process has been recently developed.

Microbial Fuel Cells (MFC) provide a new approach for wastewater treatment, and especially generate electricity from conversion of organic and inorganic matter (Logan et al., 2006). According to literature review, the sulfide removal and nitrate/nitrite removal have been studied separately in MFC (Rabaey et al., 2006; Sun et al., 2009; Clauwaert et al., 2007; Puig et al., 2011). Theoretically, they can also be removed simultaneously in MFC (Eq. (1)):

$$5HS^- + 2NO_3^- \rightarrow 5S^0 + N_2 + 6H_2O + 7e^- \Delta G_m^0 = -1264\ \text{KJ per reaction}\ E^0 = 1.87\ \text{V} \quad (1)$$

So far, however, few studies have been reported about the simultaneous sulfide and nitrate removal in MFC. Lee et al. (2012) investigated the interactions between denitrifying sulfide

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http://dx.doi.org/10.1016/j.biortech.2012.11.008