Bioresource Technology 128 (2013) 454–460

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Animal carcass wastewater treatment and bioelectricity generation in up-flow tubular microbial fuel cells: Effects of HRT and non-precious metallic catalyst

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HIGHLIGHTS

- This study is the first attempt to test the feasibility of bioelectricity generation from ACW.
- MFC could harvest power from ACW simultaneously accomplish wastewater treatment.
- MnO_2 could serve as an alternative of catalysts for ORR in an air-cathode MFC.
- The effects of MnO_2 loading and HRT on MFCs performance were investigated.

ARTICLE INFO

Article history:
Received 31 July 2012
Received in revised form 10 October 2012
Accepted 11 October 2012
Available online 23 October 2012

Keywords:
Microbial fuel cell
Animal carcass wastewater
Wastewater treatment
Power generation
Non-precious metallic catalyst

ABSTRACT

Animal carcass wastewater (ACW) is a kind of typical high concentration organic wastewater. Up-flow tubular air cathode microbial fuel cells (MFCs) were constructed using 0, 4.0 and 8.0 mg/cm^2 MnO_2 as cathodic catalyst, respectively (MFC-0, MFC-4 and MFC-8) to test the feasibility of bioelectricity production from ACW. After a start-up period of around 55d, when hydraulic retention time (HRT) was set at 3d, MFC-4 showed best bioelectricity performance with the maximum power density of 2.19 W/m^3 and minimum internal resistance of 30.3 Ω, as compared to MFC-0 (1.14 W/m^3, 62.6 Ω) and MFC-8 (1.49 W/m^3, 34.5 Ω). Chemical oxygen demand (COD) and nitrate removal efficiencies of MFC-4 were 50.66% and 79.76%, respectively. Switching HRT from 3d to 6d, COD and nitrate removal efficiencies sped up while the increase rates of ammonia slowed down. The results demonstrated that ACW could be the fuel of MFCs to generate bioelectricity.

1. Introduction

An annual production of animal by-products and mortalities in the U.S. livestock industry is approximately 63 billion pounds (Walker et al., 2004). This number, while already considerable, continues to escalate in the event of accidental disease entry, natural disaster, or an act of terrorism. Meanwhile, the death of zoo animals, pets and wildlife may also increase the number. If not timely and appropriately disposed of, large-scale decaying carcasses would pose a great risk to human and animal health or the environment (i.e., the contamination of soil, groundwater and surface water). Nevertheless, alkaline hydrolysis has proven to be a superior alternative to incineration and burial as a method for treatment and disposal of animal carcasses, with less environment impact and lower operating costs (Sander et al., 2002). The naturally-occurring process is accelerated in the alkaline hydrolysis tissue digester, where a strong alkaline substance (sodium hydroxide or potassium hydroxide), a high temperature (150 °C, 6 h) and a high pressure (at least 4 bars) are combined to solubilize and hydrolyze animal tissues. Animal carbohydrates, lipids, proteins, nucleic acids, as well as any pathogenic microorganisms, including RNA and DNA viruses, are converted into a sterile solution composed of amino acids, small peptides, sugars, and soap, along with the minerals from the bones and teeth (Kaye et al., 1998; Thacker, 2004). Therefore, the solution, termed as animal carcass wastewater (ACW), is generated during the treatment and disposal of animal carcasses.

The ACW is a sterile, coffee-colored, alkaline solution with a soap-like odor, which contains high amounts of biochemical oxygen demand (BOD, 70 g/l), chemical oxygen demand (COD, 105 g/l), ammonia (1 g/l), organic nitrogen (8 g/l) and total phosphorus (0.4 g/l) (Das, 2008). The composition and the amount of ACW

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http://dx.doi.org/10.1016/j.biortech.2012.10.053