Bioresource Technology 129 (2013) 281–288

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Suppression of methanogenesis in cellulose-fed microbial fuel cells in relation to performance, metabolite formation, and microbial population

Hamid Rismani-Yazdi [a,1], Sarah M. Carver [b,c,2], Ann D. Christy [a,*], Zhongtang Yu [d], Kyle Bibby [e,3], Jordan Peccia [e], Olli H. Tuovinen [b,c]

[a] Department of Food, Agricultural and Biological Engineering, Ohio State University, 590 Woody Hayes Drive, Columbus, OH 43210, USA
[b] Department of Microbiology, Ohio State University, 484 West 12th Ave., Columbus, OH 43210, USA
[c] Department of Chemistry and Bioengineering, Tampere University of Technology, FI-33101 Tampere, Finland
[d] Department of Animal Sciences, Ohio State University, 2029 Fyffe Road, Columbus, OH 43210, USA
[e] Department of Chemical and Environmental Engineering, Yale University, 9 Hillhouse Ave., New Haven, CT 06520, USA

HIGHLIGHTS

- ▶ Methanogenesis was active in cellulose-fed MFCs but declined on prolonged operation.
- ▶ Coulombic efficiencies increased as methanogenesis became undetectable.
- ▶ Acetic acid was the main metabolite of cellulose degradation in MFCs.
- ▶ Bacterial and archaeal diversities decreased over the 90 day operation.
- ▶ *Firmicutes*, *Methanoculleus*, and *Methanobrevibacter* were the most dominant.

ARTICLE INFO

Article history:
Received 12 September 2012
Received in revised form 24 October 2012
Accepted 26 October 2012
Available online 9 November 2012

Keywords:
Cellulose
Methanogens
Microbial fuel cells
454 Pyrosequencing
16S rRNA

ABSTRACT

The objective of this work was to evaluate methanogenesis in relation to the changes in performance and microbial diversity of cellulose-fed microbial fuel cells (MFCs). Replicate MFCs were inoculated with a ruminal microbial consortium and operated under 20 ($R_{20\Omega}$) or 100 Ω ($R_{100\Omega}$) external resistances. During the first week of operation, 0.31 and 0.44 mmol $l^{-1}$of methane were produced in the $R_{20\Omega}$ and $R_{100\Omega}$ MFCs, respectively. Methanogenesis was, however, suppressed to undetectable levels within 90 days of operation, accompanied with increased current production and improved coulombic efficiency. Suppressed methanogenesis coincided with changes in the concentrations of short chain fatty acids and a decrease in the microbial diversity. The results demonstrated that methanogenesis was active during the early stage of cellulose-fed MFCs but this activity declined over prolonged operation.

1. Introduction

Microbial fuel cells (MFCs) represent a sustainable technology for treating wastes and generating renewable electricity. Efforts have been made in recent years to improve the power output of MFCs by optimizing reactor design, electrode composition, and other engineering aspects in both the anode and cathode chambers (Qiao et al., 2010). Relatively less effort has been devoted to improving substrate oxidation efficiency, electron donation to the closed circuit, and preventing undesirable side reactions (He et al., 2005; Kim et al., 2005). MFCs inoculated with mixed microbial populations inevitably have concurrent metabolic pathways that may lead to undesirable side reactions that drain electrons away from the circuit.

The ideal biochemical premise for electricity generation in MFCs is the transfer of electrons to the anode through microbial electron transport systems. Some microorganisms have been shown to transfer electrons to the anode via electrically conductive pili and biofilm formation but these interactions are poorly understood (Logan, 2009). Other mechanisms may include direct transfer of electrons via microbial cytochromes or excreted mediators (Logan, 2009). In MFCs fed with wastewater or biomass polymers,

* Corresponding author. Tel.: +1 (614) 292 3171; fax: +1 (614) 292 9448.
E-mail address: christy.14@osu.edu (A.D. Christy).
[1] Present address: Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.
[2] Present address: Department of Horticulture, Cornell University, Ithaca, NY 14853, USA.
[3] Present address: Department of Civil and Environmental Engineering, University of Pittsburgh, Pittsburgh, PA 15261, USA.

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.10.137